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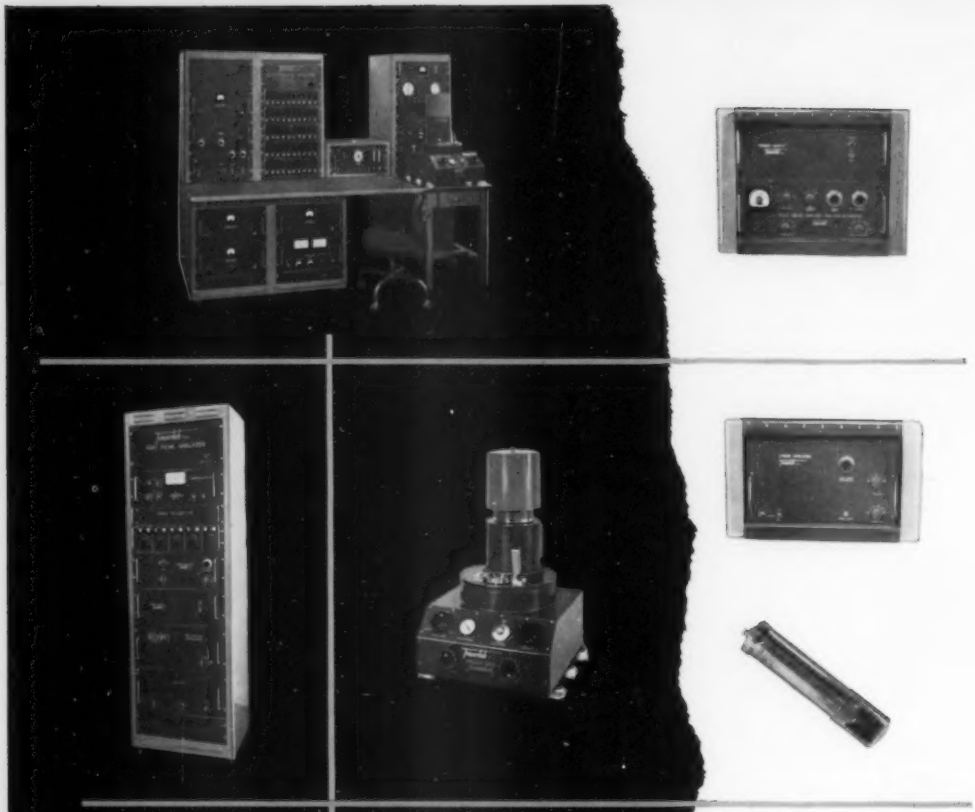

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Of Tom-Toms and Telephones

Let's face it.

Compared with current needs for the communication of technical information, our communication system is not much more adequate than tom-toms would be for transmitting, from Schenectady to Spokane, a message giving the latest developments in nuclear fission. Eventually some distorted variety of the original message would get through.

Our current system of book and report publication, sent to libraries to be cataloged and stored, is as much out of step with the times as are tom-toms for transmitting messages. Sheer bulk of reporting is too great to be kept up with by the conventional means of the receiving, cataloging, storing, and recalling. But no means has yet been devised to supplant satisfactorily conventional means for library handling of reports. Something must be done to organize, systematize, arrange in coherent recoverable order all the information that is pouring out of research and development activities in countless science specialties. We are improving perpetually the methods of getting out technical reports, but handling on the using end remains in the tom-tom stage. It is time we quit beating the tom-tom and started ringing in on an adequate system of cataloging, storing, and recovering information. Electronization seems to be the answer, but it has pitfalls that should be thoroughly investigated.

The complexity of a communication system necessary for a given civilization depends on the scale of the civilization and its degree of technologic development. Our civilization is the largest in scale and has reached the highest degree of technologic development known in history. Therefore, our communication system must be the most complex ever to function. But it can be complex without fulfilling its function. Our present-day communication system for technical materials is just such a complex but inadequate system. Since no over-all organization of technical communication exists, even to call it a system is of doubtful legitimacy.

We need a system analogous to the telephone. A telephone call, across town or across a continent, is from one person to another. One person transmits information and another receives it. No matter how complex the transmission and switching devices, the message goes through. Wrong numbers and misinformation are, by and large, the fault of the transmitting person and not of the transmitting equipment. The problem of technical communication today is to get the message from one person who has information to another who wants it. It is that simple. It is that difficult.—JOHN H. WILSON, *Editorial Branch, U.S. Naval Ordnance Test Station, China Lake, California.*

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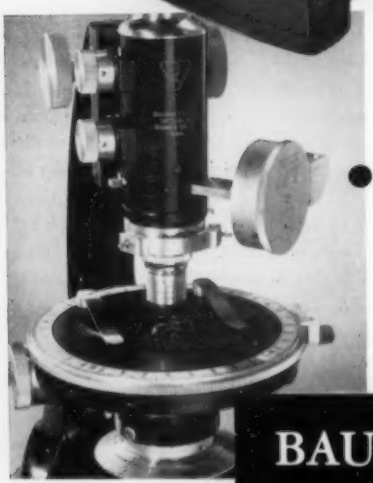

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Statistical Interpretation of Quantum Mechanics

Max Born

The published work for which the honor of the Nobel prize for the year 1954 has been accorded to me does not contain the discovery of a new phenomenon of nature but, rather, the foundations of a new way of thinking about the phenomena of nature. This way of thinking has permeated experimental and theoretical physics to such an extent that it seems scarcely possible to say anything more about it that has not often been said already. Yet there are some special aspects that I should like to discuss.

The first point is this: The work of Göttingen school, of which I was at that time the director, during the years 1926 and 1927, contributed to the solution of an intellectual crisis into which our science had fallen through Planck's discovery of the quantum of action in the year 1900. Today physics is in a similar crisis—I do not refer to its implication in politics and economics consequent on the mastery of a new and terrible force of nature, but I am thinking of the logical and epistemological problems posed by nuclear physics. Perhaps it is a good thing to remind oneself at such a time of what happened earlier in a similar situation, especially since these events are not without a certain element of drama. In the second place, when I say that physicists had accepted the way of thinking developed by us at that time, I am not quite correct. There are a few most noteworthy exceptions—namely, among those very workers who have contributed most to the building up of quantum theory. Planck himself belonged to the skeptics until his death. Einstein, de Broglie, and Schrödinger have not ceased to emphasize the unsatisfactory features of quantum mechanics, and to demand a return to the concepts of classical, Newtonian physics, and to propose ways in which this could be done without contradicting experimental facts. One cannot leave such weighty views unheard. Niels Bohr has gone to much trouble to refute the objections. I have myself pondered on them and believe I can contribute something to the clarification of the situation. We are concerned with the borderland between physics and philosophy, and so my physical lecture will be partly historically and partly philosophically colored, for which I ask indulgence.

Dr. Born presently resides at Marcardstrasse 4, Bad Pyrmont, West Germany. He was formerly professor and director of the Institute for Theoretical Physics in Göttingen, Stokes' lecturer in mathematics at the University of Cambridge, and Tait professor of natural philosophy at the University of Edinburgh. This article is based on the lecture that he gave when he was awarded the Nobel prize for physics in 1954, a prize that he shared with Walter Bothe. Dr. Born's manuscript was translated by Robert Schlapp, Department of Mathematical Physics, University of Edinburgh, Scotland, and is published here with permission of the Nobel Foundation. Dr. Bothe's Nobel lecture will appear in a subsequent issue.

Roots of Quantum Mechanics

First of all, let me relate how quantum mechanics and its statistical interpretation arose. At the beginning of the 1920's every physicist, I imagine, was convinced that Planck's hypothesis was correct, according to which the energy in oscillations of definite frequency ν (for example, in light waves) occurs in finite quanta of size $h\nu$. Innumerable experiments could be explained in this manner and always gave the same value of Planck's constant h. Furthermore, Einstein's assertion that light quanta carry momentum $h\nu/c$ (where c is the velocity of light) was well supported by experiment. This meant a new lease on life for the corpuscular theory of light for a certain complex of phenomena. For other processes, the wave theory was appropriate. Physicists accustomed themselves to this duality and learned to handle it to a certain extent.

In 1913 Niels Bohr had solved the riddle of line spectra by using quantum theory and at the same time had explained, in their main features, the wonderful stability of atoms, the structure of their electronic shells, and the periodic system of the elements. For the sequel the most important assumption of his teaching was this: an atomic system cannot exist in all mechanically possible states, which form a continuum, but in a series of "discrete stationary" states; in a transition from one to another the difference in energy $E_m - E_n$ is emitted or absorbed as a light quantum $h\nu_{mn}$ (according as E_m is greater or less than E_n). This is an interpretation, in terms of energy, of the fundamental law of spectroscopy discovered some years previously by W. Ritz. The situation can be pictured by writing the energy levels of the stationary states twice over, horizontally and vertically; a rectangular array results

	E_1	E_2	E_3 . . .
E_1	11	12	13
E_2	21	22	23

in which positions on the diagonal correspond to the states and off-diagonal positions correspond to the transitions.

Bohr was fully aware that the law thus formulated is in conflict with mechanics and that, therefore, even the use of the concept of energy in this context is problematical. He based this bold fusion of the old with the new on his principle of correspondence. This consists in the obvious requirement that ordinary classical mechanics must hold to a high degree of approximation in the limit, when the numbers attached to the stationary states, the quantum numbers, are very large—that is, far to the right and low down in the foregoing array—so that the energy changes relatively little from place to place—that is, practically continuously.

Theoretical physics lived on this idea for the next 10 years. The problem was

that a harmonic oscillator possesses not only frequency but intensity as well. For each transition in the scheme there must be a corresponding intensity. How is the latter to be found by considerations of correspondence? It was a question of guessing the unknown from a knowledge of a limiting case. Considerable success was achieved by Bohr himself, by Kramers, by Sommerfeld, by Epstein, and by many others. But the decisive step was again taken by Einstein, who, by a new derivation of Planck's radiation formula, made it evident that the classical concept of intensity of emission must be replaced by the statistical idea of transition probability. To each position in our scheme there belongs, besides the frequency $\nu_{mn} = (E_m - E_n)/h$, a certain probability for the transition accompanied by emission or absorption of radiation.

In Göttingen we also took part in the attempts to distill the unknown mechanics of the atom out of the experimental results. The logical difficulty became ever more acute. Investigations on scattering and dispersion of light showed that Einstein's conception of transition probability as a measure of the strength of an oscillation was not adequate, and the idea of an oscillation amplitude associated with each transition could not be dispensed with. In this connection work by Ladenburg (*1*), Kramers (*2*), Heisenberg (*3*), Jordan and I (*4*) may be mentioned. The art of guessing correct formulas, which depart from the classical formulas but pass over into them in the sense of the correspondence principle, was brought to considerable perfection. A paper of mine, which introduced in its title the expression "quantum mechanics," probably for the first time, contains a very involved formula—still valid at the present time—for the mutual disturbance of atomic systems.

Heisenberg's Theory

This period was brought to a sudden end by Heisenberg (*5*), who was my assistant at that time. He cut the Gordian knot by a philosophic principle and replaced guesswork by a mathematical rule. The principle asserts that concepts and pictures that do not correspond to physically observable facts should not be used in theoretical description. When Einstein, in setting up his theory of relativity, eliminated the concepts of the absolute velocity of a body and of the absolute simultaneity of two events at different places, he was making use of the same principle. Heisenberg banished the picture of electron orbits with definite radii and periods of rotation, because these quantities are not observable; he demanded that the theory should be built up by means of quadratic arrays of the kind suggested in a preceding paragraph. Instead of describing the motion by giving a coordinate as a function of time $x(t)$, one ought to determine an array of transition probabilities x_{mn}. To me the decisive part in his work is the requirement that one must find a rule whereby from a given array

$$\begin{matrix} x_{11} & x_{12} & \cdots \\ x_{21} & x_{22} & \\ \vdots & & \end{matrix}$$

the array for the square,

$$\begin{matrix} (x^2)_{11} & (x^2)_{12} & \cdots \\ (x^2)_{21} & (x^2)_{22} & \\ \vdots & & \end{matrix}$$

may be found (or, in general, the multiplication law of such arrays).

By consideration of known examples discovered by guesswork he found this rule and applied it with success to simple examples such as the harmonic and anharmonic oscillator. This was in the summer of 1925. Heisenberg, suffering from a severe attack of hay fever, took leave of absence for a course of treatment at the seaside and handed over his paper to me for publication, if I thought I could do anything about it.

The significance of the idea was immediately clear to me, and I sent the manuscript to the *Zeitschrift für Physik*. Heisenberg's rule of multiplication left me no peace, and after a week of intensive thought and trial, I suddenly remembered an algebraic theory that I had learned from my teacher, Rosanes, in Breslau. Such quadratic arrays are quite familiar to mathematicians and are called matrices, in association with a definite rule of multiplication. I applied this rule to Heisenberg's quantum condition and found that it agreed for the diagonal elements. It was easy to guess what the remaining elements must be, namely, null; and immediately there stood before me the strange formula

$$pq - qp = h/2\pi.$$

This meant that coordinates q and momenta p are not to be represented by the values of numbers but by symbols whose product depends on the order of multiplication—which do not "commute," as we say.

My excitement over this result was like that of the mariner who, after long voyaging, sees the desired land from afar, and my only regret was that Heisenberg was not with me. I was convinced from the first that we had stumbled on the truth. Yet again a large part was only guesswork, in particular the vanishing of the nondiagonal elements in the foregoing expression. For this problem I secured the collaboration of my pupil Pascual Jordan, and in a few days we succeeded in showing that I had guessed correctly. The joint paper by Jordan and myself (*6*) contains the most important principles of quantum mechanics, including its extension to electrodynamics.

There followed a hectic period of collaboration among the three of us, rendered difficult by Heisenberg's absence. There was a lively interchange of letters, my contribution to which unfortunately went amiss in the political disorders. The result was a three-man paper (*7*), which brought the formal side of the investigation to a certain degree of completeness. Before this paper appeared, the first dramatic surprise occurred: Paul Dirac's paper (*8*) on the same subject. The stimulus received through a lecture by Heisenberg in Cambridge led him to results similar to ours in Göttingen, with the difference that he did not have recourse to the known matrix theory of the mathematician but discovered for himself and elaborated the doctrine of such noncommuting symbols.

The first nontrivial and physically important application of quantum mechanics was made soon afterward by W. Pauli (*9*), who calculated the stationary energy values of the hydrogen atom by the matrix method and found complete agreement with Bohr's formulas. From this moment there was no longer any doubt about the correctness of the theory.

Wave Mechanics

What the real significance of this formalism might be was, however, by no means clear. Mathematics, as often happens, was wiser than interpretative thought. While we were still discussing the point, there occurred the second dramatic surprise: the appearance of Schrödinger's celebrated papers (*10*). He followed quite a different line of thought, which derived from Louis de Broglie (*11*). The latter had a few years previously made the bold assertion, supported by brilliant theoretical considerations, that wave-corpuscle dualism, familiar to physicists in the case of light, must also be exhibited by electrons; to each freely movable electron there belongs, according to these ideas, a plane wave of perfectly definite wavelength, determined by Planck's constant and the mass. This exciting essay by de Broglie was well known to us in Göttingen.

One day in 1925 I received a letter from C. J. Davisson containing singular results on the reflection of electrons from metallic surfaces. My colleague on the experimental side, James Franck, and I at once conjectured that these curves of Davisson's were crystal-lattice spectra of de Broglie's electron

waves, and we arranged for one of our pupils, W. Elsasser (*12*) to investigate the matter. His result provided the first quantitative proof of de Broglie's idea, a proof independently given later by Davisson and Germer (*13*) and by G. P. Thomson (*14*), by systematic experiments.

But this familiarity with de Broglie's line of thought did not lead on further toward an application to the electronic structure of atoms. This was reserved for Schrödinger. He extended de Broglie's wave equation, which applied to free motion, to the case in which forces act and gave an exact formulation of the additional conditions, already hinted at by de Broglie, to which the wave function ψ must be subjected—namely, that it should be single-valued and finite in space and time—and he succeeded in deriving the stationary states of the hydrogen atom as monochromatic solutions of his wave equation not extending to infinity. For a short while, at the beginning of 1926, it looked as if suddenly there were two self-contained but entirely distinct systems of explanation in the field—matrix mechanics and wave mechanics. But Schrödinger himself soon demonstrated their complete equivalence.

Wave mechanics enjoyed much greater popularity than the Göttingen or Cambridge version of quantum mechanics. Wave mechanics operates with a wave function ψ, which—at least in the case of one particle—can be pictured in space, and it employs the mathematical methods of partial differential equations familiar to every physicist. Schrödinger also believed that his wave theory made possible a return to deterministic classical physics; he proposed (and has emphatically renewed this suggestion quite recently, *15*) to abandon the particle picture entirely and to speak of electrons not as particles but as a continuous density distribution $|\psi|^2$, or electric density $e|\psi|^2$.

To us in Göttingen this interpretation appeared unacceptable in the face of the experimental facts. At that time it was already possible to count particles by means of scintillations or with the Geiger counter and to photograph their tracks with the help of the Wilson cloud chamber.

Max Born

Psi-function

It appeared to me that it was not possible to arrive at a clear interpretation of the ψ-function by considering bound electrons. I had therefore been at pains, as early as the end of 1925, to extend the matrix method, which obviously covered only oscillatory processes, in such a way as to be applicable to aperiodic processes. I was at that time the guest of the Massachusetts Institute of Technology in the U.S.A., and there I found in Norbert Wiener a distinguished collaborator. In our joint paper (*16*) we replaced the matrix by the general concept of an operator and, in this way, made possible the description of aperiodic processes. Yet we missed the true approach, which was reserved for Schrödinger; and I immediately took up his method, since it promised to lead to an interpretation of the ψ-function. Once more an idea of Einstein's gave the lead. He had sought to make the duality of particles (light quanta or photons) and waves comprehensible by interpreting the square of the optical wave amplitudes as probability density for the occurrence of photons. This idea could at once be extended to the ψ-function: $|\psi|^2$ must represent the probability density for electrons (or other particles). To assert this was easy; but how was it to be proved?

For this purpose atomic scattering processes suggested themselves. A shower of electrons coming from an infinite distance, represented by an incident wave of known intensity (that is, $|\psi|^2$) impinge on an obstacle, say a heavy atom. In the same way that the water wave caused by a steamer excites secondary circular waves in striking a pile, the incident electron wave is partly transformed by the atom into a secondary spherical wave, whose amplitude of oscillation ψ is different in different directions. The square of the amplitude of this wave at a great distance from the scattering center then determines the relative probability of scattering in its dependence on direction. If, in addition, the scattering atom is itself capable of existing in different stationary states, one also obtains quite automatically from Schrödinger's wave equation the probabilities of excitation of these states, the electron being scattered with loss of energy, or inelastically, as it is termed. In this way it was possible to give the assumptions of Bohr's theory, first verified experimentally by Franck and Hertz, a theoretical basis (*17*). Soon Wentzel (*18*) succeeded in deriving Rutherford's celebrated formula for the scattering of α-particles from my theory.

But the factor that contributed more than these successes to the speedy acceptance of the statistical interpretation of the ψ-function was a paper by Heisenberg (*19*) that contained his celebrated uncertainty relationship, through which the revolutionary character of the new conception was first made clear. It appeared that it was necessary to abandon not only classical physics but also the naive conception of reality that thought of the particles of atomic physics as if they were exceedingly small grains of sand. A grain of sand has at each instant a definite position and velocity. For an electron this is not the case; if one determines the position with increasing accuracy, the possibility of determining the velocity becomes less, and vice versa. I shall return to these questions in a more general connection, but before doing so would like to say a few words about the theory of collisions.

The mathematical techniques of approximation I used were somewhat primitive and were soon improved. Out of the literature, which has grown to unmanageable proportions, I can name only a few of the earliest authors, to whom the theory is indebted for considerable progress: Holtsmark in Norway, Faxén in Sweden, Bethe in Germany, Mott and Massey in Great Britain.

Today collision theory is a special science, with its own voluminous textbooks, and has grown completely over my head. Of course, in the last resort all the modern branches of physics, quantum electrodynamics, the theory of mesons, nuclei, cosmic rays, elementary particles and their transformations, all belong to this range of ideas, to a discussion of which no bounds could be set.

Probability of Transitions

I should also like to state that during the years 1926 and 1927 I tried another way of justifying the statistical conception of quantum mechanics, partly in collaboration with the Russian physicist Fock (*20*). In the afore-mentioned threeman paper there is a chapter in which the Schrödinger function is really anticipated; only it is not thought of as a function ψ of space, but as function ψ_n of the discrete index $n = 1, 2, \ldots$ which enumerates the stationary states. If the system under consideration is subject to a force that is variable in time, ψ_n also becomes time-dependent, and $|\psi_n(t)|^2$ denotes the probability for the existence of that state n at time t.

Starting from an initial distribution in which only one state is present, we ob-

tain in this manner transition probabilities, and we can investigate their properties. In particular, what interested me most at the time was what happens in the adiabatic limiting case, that is, in the case of very slowly variable external action; it was possible to show that, as might have been expected, the probability of transitions became ever smaller. The theory of transition probabilities was developed independently by Dirac and made to yield results. It may be said that the whole of atomic and nuclear physics works with this system of concepts, especially in the extremely elegant form given to them by Dirac (*21*); almost all experiments lead to statements about relative probabilities of events, even if they appear concealed under the name cross section or the like.

How then does it come about that great discoverers such as Einstein, Schrödinger, and de Broglie are not satisfied with the situation? As a matter of fact, all these objections are directed not against the correctness of the formulas but against their interpretation. Two closely interwoven points of view must be distinguished: the question of determinism and the question of reality.

Newtonian mechanics is deterministic in the following sense. If the initial state (positions and velocities of all particles) of a system is accurately given, the state at any other time (earlier or later) may be calculated from the laws of mechanics. All the other branches of classical physics have been built up in accordance with this pattern. Mechanical determinism gradually became an article of faith—the universe as a machine, an automaton. As far as I can see, this idea has no precursors in ancient or medieval philosophy; it is a product of the immense success of Newtonian mechanics, especially in astronomy. In the 19th century it became a fundamental philosophic principle for the whole of exact science. I asked myself whether this was really justified. Can we really make absolute predictions for all time on the basis of the classical equations of motion? It is easily seen, by simple examples, that this is the case only if we assume the possibility of absolutely accurate measurement (of the position, velocity, or other quantities). Let us consider a particle moving without friction on a straight line between two endpoints (walls) at which it suffers perfectly elastic recoil, The particle moves backward and forward with constant speed equal to its initial speed v_0, and one can say exactly where it will be at a stated time provided that v_0 is accurately known.

But if we allow a small inaccuracy Δv_0, the inaccuracy of the prediction of position at time t is $t\Delta v_0$; that is, it increases with t. If we wait long enough, until time $t_c = l/\Delta v_0$, where c is the distance between the elastic walls, the inaccuracy Δx will have become equal to the whole interval l. Thus it is possible to say absolutely nothing about the position at a time later than t_c. Determinism becomes complete indeterminism if one admits even the smallest inaccuracy in the velocity datum. Is there any sense—I mean physical, not metaphysical, sense—in which one can speak of absolute data? Is it justifiable to say that the coordinate x is π cm, where $\pi = 3.1415\ldots$ is the familiar transcendental number that determines the ratio of the circumference of a circle to its diameter? As an instrument of mathematics, the concept of a real number represented by a nonterminating decimal is extremely important and fruitful. As a measure of a physical quantity, the concept is nonsensical. If the decimal for π is interrupted at the 20th or 25th place, two numbers are obtained which cannot be distinguished by any measurement from each other and from the true value. According to the heuristic principle employed by Einstein in the theory of relativity and by Heisenberg in quantum theory, concepts that correspond to no conceivable observation ought to be eliminated from physics. This is possible without difficulty in the present case also; we have only to replace statements like $x = \pi$ cm by: the probability of the distribution of values of x has a sharp maximum at $x = \pi$ cm; and (if we wish to be more accurate) we can add: of such and such a breadth. In short, ordinary mechanics must be formulated statistically. I have occupied myself with this formulation a little recently and have seen that it is possible without difficulty. This is not the place to go into the matter more closely. I only wish to emphasize the point that the determinism of classical physics turns out to be a false appearance, produced by ascribing too much weight to mathematicological conceptual structures. It is an *idol,* not an *ideal,* in the investigation of nature and, therefore, cannot be used as an objection to the essentially indeterministic, statistical interpretation of quantum mechanics.

Much more difficult is the objection concerned with reality. The concept of a particle, for example, a grain of sand, contains implicitly the notion that it is at a definite position and has a definite motion. But according to quantum mechanics it is impossible to determine simultaneously with arbitrary accuracy position and motion (more correctly momentum, that is, mass times velocity). Thus two questions arise. First, what is there to prevent us from measuring both quantities with arbitrary accuracy by refined experiments, in spite of the theoretical assertion? Second, if it should really turn out that this is not feasible, are we still justified in applying to the electron the concept of particle and the ideas associated with it?

With regard to the first question, it is clear that if the theory is correct—and we have sufficient grounds for believing this—the obstacle to simultaneous measurability of position and motion (and of other similar pairs of so-called "conjugate" quantities) must lie in the laws of quantum mechanics itself. This is indeed the case, but it is not at all obvious. Niels Bohr himself has devoted much labor and ingenuity to developing a theory of measurements to clear up this situation and to meet the most subtle considerations of Einstein, who repeatedly tried to think out measuring devices by means of which position and motion could be measured simultaneously and exactly. The conclusion is as follows. In order to measure space coordinates and instants of time rigid measuring rods and clocks are required. On the other hand to measure momenta and energies arrangements with movable parts are needed to take up and indicate the impact of the object to be measured. If we take into consideration the fact that quantum mechanics is appropriate for dealing with the interaction of object and apparatus, we see that no arrangement is possible that satisfies both conditions at the same time. There exist, therefore, mutually exclusive but complementary experiments, which only in combination with each other disclose all that can be learned about an object. This idea of complementarity in physics is generally regarded as the key to the intuitive understanding of quantum processes. Bohr has transferred the idea in an ingenious manner to completely different fields—for example, to the relationship between consciousness and brain, to the problem of free will, and to other fundamental problems of philosophy.

Now to come to the final point—can we still call something with which the concepts of position and motion cannot be associated in the usual way a *thing,* a *particle*? And if not, what is the reality that our theory has been invented to describe?

The answer to this question is no longer physics, but philosophy, and to deal with it completely would overstep the bounds of this lecture. I have expounded my views on it fully elsewhere (*23*). Here I will only say that I am emphatically for the retention of the particle idea. Naturally it is necessary to redefine what is meant. For this purpose well-developed concepts are available, which are familiar in mathematics under the name of invariants with respect to transformations. Every object that we perceive appears in innumerable aspects.

The concept of the object is the invariant of all these aspects. From this point of view, the present universally used conceptual system, in which particles and waves occur at the same time, can be completely justified.

The most recent research on nuclei and elementary particles has, however, led us to limits beyond which this conceptual system in its turn does not appear to suffice. The lesson to be learned from the story I have told of the origin of quantum mechanics is that, presumably, a refinement of mathematical methods will not suffice to produce a satisfactory theory, but that somewhere in our doctrine there lurks a conception not justified by any experience, which will have to be eliminated in order to clear the way.

References

1. R. Ladenburg, *Z. Physik* **4**, 451 (1921); R. Ladenburg and F. Reiche, *Naturwiss.* **11**, 584 (1923).
2. H. A. Kramers, *Nature* **113**, 673 (1924).
3. ———and W. Heisenberg, *Z. Physik* **31**, 681 (1925).
4. M. Born, *ibid.* **26**, 379 (1924); M. Born and P. Jordan, *ibid.* **33**, 479 (1925).
5. W. Heisenberg, *ibid.* **33**, 879 (1925).
6. M. Born and P. Jordan, *ibid.* **34**, 858 (1925).
7. M. Born, W. Heisenberg, P. Jordan, *ibid.* **35**, 557 (1926).
8. P. A. M. Dirac, *Proc. Roy Soc.* (*London*) **A109**, 642 (1925).
9. W. Pauli, *Z. Physik* **36**, 336 (1926).
10. E. Schrödinger, *Ann. Physik* (4), **79**, 361, 489, 734 (1926); **80**, 437 (1926); **81**, 109 (1926).
11. Louis de Broglie, Thèses, Paris, 1924; *Ann. Physik* (10), **3**, 22 (1925).
12. W. Elsasser, *Naturwiss.* **13**, 711 (1925).
13. C. J. Davisson and L. H. Germer, *Phys. Rev.* **30**, 707 (1927).
14. G. P. Thomson and A. Reid, *Nature* **119**, 890 (1927); G. P. Thomson, *Proc. Roy Soc.* (*London*) **A117**, 600 (1928).
15. E. Schrödinger, *Brit. J. Phil. Sci.* **3**, 109, 233 (1952).
16. M. Born and N. Wiener, *Z. Physik* **36**, 174 (1926).
17. M. Born, *ibid.* **37**, 863 (1926); **38**, 803 (1926); *Gött. Nachr. Math.-Physik* **K1. 1**, 146 (1926).
18. G. Wentzel, *Z. Physik* **40**, 590 (1926).
19. W. Heisenberg *ibid.* **43**, 172 (1927).
20. M. Born, *ibid.* **40**, 167 (1926); M. Born and V. Fock, *ibid.* **51**, 165 (1928).
21. P. A. M. Dirac, *Proc. Roy. Soc.* (*London*) **A109**, 642 (1925); **110**, 561 (1926); **111**, 281 (1926); **112**, 674 (1926).
22. Niels Bohr, *Naturwiss.* **16**, 245 (1928); **17**, 483 (1929); **21**, 13 (1933); "Causality and complementarity," *Die Erkenntnis* **6**, 293 (1936).
23. M. Born, *Phil. Quart.* **3**, 134 (1953); *Physik Bl.* **10**, 49 (1954).

C. T. Brues, Zoologist

Charles Thomas Brues, professor emeritus of entomology at Harvard University, died in Crescent City, Florida, on 22 July 1955. He was born in Wheeling, West Virginia, on 20 June 1879. The family moved to Chicago in 1893, and the following year Brues, with a fellow-student, Axel Leonard Melander, attended the North Division High School in Chicago. This was a significant event, for under the tutelage of the principal, Oliver S. Wescott, and the biology teacher at the school, Herbert Eugene Walter, the boys were inspired to undertake a serious study of insects.

On graduation from high school Brues and Melander entered the University of Texas to study under W. M. Wheeler, who had just been appointed there. After taking his A.B. degree in 1901 and his M.S. degree in 1902, Brues went to Columbia University for 2 years, subsequently returning to Texas as a special field agent in entomology for the U.S. Department of Agriculture. It was at this time that he married Beirne Barrett, a former biology major at the University of Texas.

In 1905 he was appointed curator of invertebrate zoology at the Milwaukee Public Museum but left there in 1909 to join Wheeler, who was then professor of entomology and dean of the Bussey Institution at Harvard University. Brues was appointed instructor in economic entomology and advanced through the several ranks, becoming professor of entomology in 1935. Just prior to this, in 1932, the Bussey Institution was abolished as a separate graduate school, and Brues and Wheeler moved their offices to the Biological Laboratories in Cambridge, the headquarters of the department of biology. In 1946 Brues was appointed professor emeritus and honorary curator of parasitic hymenoptera in the Museum of Comparative Zoology.

Brues was broadly interested in all aspects of insects and, indeed, in all biological phenomena. Although most of his research was of a taxonomic nature, his investigations also included such diverse subjects as the ecology of thermophilous animals, the food and feeding habits of insects, insect paleontology, medical entomology, fluorescent staining of insect tissues, and intracellular bacteroids of insects. His early publications were devoted mainly to the taxonomy and biology of myrmecophilous insects, especially phorid flies; later papers also dealt with taxonomic studies on parasitic Hymenoptera, including the fossil forms in Baltic amber and in the Florissant shales of Colorado. His bibliography contains 280 titles. Several of his publications appeared in book form: *A Key to the Families of North American Insects* (with A. L. Melander), 1915; *Insects and Human Welfare* (1921 and 1947); *Insect Dietary* (1946); and the *Classification of Insects* (with A. L. Melander), which went through three printings in the first edition. The revised and enlarged edition of the latter (1954), with F. M. Carpenter as a third author, was the last of Brues' publications.

In connection with his investigations, Brues made a number of field trips; on these he was usually accompanied by Mrs. Brues, a biologist in her own right and the author of several botanical papers. In addition to many collecting expeditions in this country, he went to Jamaica in 1911–12, Peru and Ecuador in 1913 (Harvard Medical Expedition), Cuba in 1926–27, Hudson Bay in 1936 (amber insect collecting), Dutch East Indies, Sumatra, Java, Celebes, and Bali in 1937, and the Philippines in 1949.

Brues took great interest in the Cambridge Entomological Club and was the editor of *Psyche*, the club's journal, from 1910 to 1947. He took an active part in other scientific societies and served as president of the Entomological Society of America in 1929.

His teaching at Harvard was very effective, especially at the graduate level. He was unusually close to his students and was always available to them for friendly and informal discussions. He was a wise counselor whose greatest strength was in his humility and in his devotion to truth.

A. L. Melander

Riverside, California

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Agriculture in the Zone of Perpetual Frost

Nestor Korol

Eternal frost is spread over a wide expanse of the land area of our earth. It covers up to 25 percent of the total surface of the land of our planet.

The zone of perpetual frost in the Northern Hemisphere embraces almost the whole surface from the North Polar Circle (with the exception of some of the areas on the Scandinavian Peninsula), southward to the Asiatic and North American continents (Alaska and the northern part of Canada). In the Southern Hemisphere, eternal frost expands over the entire continent of Antarctica and the islands lying between the Antarctic and the South American continent. Also, areas where perpetual frost reigns supreme can be found in the mountainous regions of all continents, with the exception of Australia.

In the Soviet Union, the zone of perpetual frost comprises an area of 10.5 million square kilometers, or almost half of the entire territory of the U.S.S.R. About 7 million square kilometers of land—that is, one-third of the entire territory of the U.S.S.R.—is located in the belt of perpetual frost where the soil does not thaw enough to make its cultivation possible. The remaining 3.5 million square kilometers of land is in the subzone of the so-called "seasonal" perpetual frost, which thaws in summer to a degree more or less sufficient for agricultural cultivation. However, the layers that lie deep in the earth's crust remain in an eternally frozen state. The larger part of Siberia and the northern part of European U.S.S.R. are within the zone of perpetual frost, and this explains the intensive interest of the Soviets in this zone and their efforts in studying the phenomena of perpetual frost.

Perpetual frost, as the name may suggest, is a natural phenomenon that leaves certain layers of the earth's crust in a state of permanent congelation. These layers are to be found at a certain depth from the surface, and they continuously preserve a freezing temperature. Eternal frost is the result of a combination of low temperatures of the air in a given locality and a great many diverse physicogeographic conditions in the successive historical-geologic development.

The thickness of a snow covering on the surface of the earth, the thickness of moss growth and of peat, the broken-up physical relief of the locality—all these, apart from the low temperatures of the air, play a decisive part in the process of the formation of perpetual frost. And finally, the reason for its formation is in the greater loss than gain of warmth by the earth's crust, resulting in the crust's freezing to a greater extent in winter than it thaws in summer. The perpetual frost's origin is ages old, but in some places it is only of current or fairly recent date. Its ancient origin is confirmed by the presence in the eternally frozen layers of the carcasses of the mammoth, the haired rhinoceros, and other long-extinct animals whose carcasses have shown no signs of decomposition, as if they had been frozen only recently, and also by the presence of thick layers of ice in the earth's crust. Confirming the more recent origin of perpetual frost in various localities are the discoveries in the eternally frozen layers of objects of human usage and even human bodies, along with those of horses, which have been preserved perfectly. This was the case in the discovery of the Scythian graves in the Altay in which the bodies had been laid 2000 years ago.

The depth of the frozen layers is not uniform. As a rule, the more southerly, the thinner it becomes. Thus, for instance, on the shores of the Laptevykh Sea, perpetual frost reaches more than 500 meters into the crust of the earth; in central Yakutian region, to about 200 meters deep; in the eastern part of Chita region, up to 70 meters deep; in the latter's southern reaches, to 30 to 50 meters; in the southernmost part of the perpetual frost belt—beyond the limits of the Soviet Union, that is, in Mongolia and Manchuria—it is no more than 1 to 2 meters below the thawed horizon of the earth's crust.

The temperature of the permanently frozen crust also varies with the place—from −35°C in the north to 1° below zero in the south. The clearing of woods, brush, moss, and peat from the surface and the measures taken to increase the thickness of the snow covering on the cleared areas in winter considerably alter the regime of perpetual frost with regard to the temperature of the subsoil and increase the depth of the thawing layer of the crust in summer. Also, the regime of perpetual frost is disturbed by constructions and their proximity to each other, in particular, by those that exude considerable warmth.

The presence of perpetual frost, obviously, constitutes great obstacles and difficulties for the economic activities of man, such as the construction of roads, canals, water supply systems.

This article is concerned with perpetual frost exclusively as it affects the possibilities of agriculture in its zone, and then only insofar as the activities of the Scientific Research Institute of Northern Grain Farming are concerned. The institute was set up in Moscow early in 1933 with quite a dense network of experimental stations throughout the entire European and Asiatic North of the U.S.S.R. with the aim of transforming the zone of perpetual frost into an agricultural area.

On the basis of years of experience with tests for growing agricultural crops under normal production conditions at the experimental agronomic stations, it would not be a mistake to maintain that agriculture in the zone of perpetual frost will probably never assume any industrial importance. In some exceptional cases, such as in the southernmost reaches, it may secure for the family grain and vegetables on a small scale, provided that the density of the population does not increase very much. The peculiarity of the conditions of agriculture there is that a farmer must have at his disposal large areas of land, since he is constantly faced with the need of breaking new soil to replace the land that has irretrievably lost its fertility. However, in the last few years, the government has exerted efforts toward increasing greatly the density of the population in these very localities of the perpetual frost belt (as well as promoting settlement of the deserts and semideserts of Kazakhstan). The artificial augmentation of the population by new settlers will result either in their death, dispersal, or their being supplied with food imported from elsewhere.

An obstacle to the development of agriculture in the belt of perpetual frost lies in the conditions of the subsoil and

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the climate. In the so-called "active" (tillable) horizon of the soil in the perpetual frost zone, which thaws on the surface to a sufficient depth to enable cultivation of agricultural products, the changes of temperature are quite considerable, ranging between 30° and 35°C below zero in winter, and 20° to 25° above zero in summer. The temperature also varies in the thawed layer of the earth's crust during the period of vegetation. As a result of these variations, an intensive oozing takes place in the tillable soil and with it hard particles are removed.

By regulating the water regime and temperature conditions of the active soil, the depth of the deeper layer can be changed, thereby increasing the thickness of the tillable soil from which the growing plants can draw nourishment. The regulation of water and temperature conditions under natural circumstances has brought about the following changes in the depth of the active horizon of the layer as compared with the normal depth of 30 to 50 centimeters and from 10 to 30 centimeters in the less easily warmed peat layers (Table 1).

The volume of the active horizon of the soil can be increased at the expense of the perpetually frozen layer by drying up lower layers, by removing the peat and moss covering of the earth's surface, and by removing factors that shade adjacent fields in summer. It should be remembered that the perpetually frozen layers often contain a good deal of ice that occurs not only in the form of thin inclusions and ice lenses but also in the form of ice layers as thick as 10, 30, and 50 meters and more. The efforts to increase the thickness of the active horizon, suitable for agriculture, have often brought about the thawing of the thicker layers of ice in the earth's crust, that are close to the surface—after the area has been cleared of all vegetation. As a result of the thawing, the earth's crust began to soften, settle down, and even sink, thereby creating large lakes of great depth.

It often happens that a certain area cleared of woods cannot be converted into arable land, because large amounts of ice in the perpetually frozen layers begin to thaw and, instead of land, there appears a lake. Only by probing deeply into the ice layer as the first step toward tilling the soil for agriculture in the perpetual frost zone can such a surprise be avoided.

Table 1. Influence of improved water and temperature conditions on the depth of thawing of the earth's surface

Location	On sand soil (m)	Sandy loam (m)	On peat (m)
Shores of Laptevykh Sea	1.2–1.6	0.7–1.0	0.2–0.6
On the Yakutsk parallel	2.0–2.5	1.5–2.0	0.5–0.8
South of 55th parallel	3.0–4.0	1.8–2.5	0.7–1.0

With rare exceptions, all reclaimed land for agriculture requires soil amelioration, which consists of draining it. First to be reclaimed should be light soils, such as light loam, sandy loam, and sandy soils, which have greater water infiltration qualities. The ever-frozen layers under such soils bed in much deeper. Water and air penetration of such soils is more favorable than it is in soils that are heavier in their structure. In the northernmost regions, areas for agriculture must be chosen on the basis of whether they are well protected from the cold northern, northwestern, and northeastern winds during the period of vegetation and whether they have a thick snow covering in winter (valleys of rivers and lakes, basins, and so forth).

Under the influence of the ever-frozen layers, special qualities are created for the active soil with respect to water, thermal, and other conditions, varying, however, in various districts of the zone. As a result of the fact that the ever-frozen layers containing ice inclusions in the lower strata are watertight, the water is retained in the active (tillable) soil, which is then waterlogged. Excessive wetness of the soil is encountered in places where the quantity of atmospheric precipitation considerably surpasses the amount of the evaporating water from the surface of the earth and from plants.

Farther to the south excessive wetness and waterlogging of the soil occur only in rugged and lowland relief of such areas. But this cannot occur at all in elevated and well-drained parts of these areas. The movement of moisture, both in its fluid and vapor form, also has substantial influence on the water supply in the perpetually frozen soil. Even during the most vigorous frosts, some water does not freeze at all. In summer, the movement of moisture takes place in the vertical direction—from the upper layers toward the lower ones—down to the frozen layers, accumulating directly just above the latter. A characteristic phenomenon in these soils, which is undesirable from the point of view of agriculture, is the frequent presence of dry thin wash in the region of the root system of cultivated plants, although the entire active soil may be oversaturated with moisture. There may also be an excessively damp thin wash in a layer of completely dry (or of medium moisture content) active soil. The causes of such defective phenomena of moisture infiltration into certain horizons of the soil in the region of the root system of growing plants are to be looked for in hydrological, geologic, and climatological factors.

The freezing and thawing of overmoistened soils cause the mechanical disintegration of the structural elements of the soil, as a result of which such soil quickly changes into a completely structureless, hardened soil, thereby creating a strong, thick soil crust on the surface. The active soil in the zone of perpetual frost increases in volume at the moment of freezing and grows like a yeast dough. Because of the unevenness of the freezing, and the pressure, water and the dust elements in the water in the lower horizons of the active strata have forced a way to the weaker places and peculiar mounds, the so-called "bulgunyakhs," have formed. In the course of 1 year they may grow to a height of several meters, and in several years they reach a height of many tens of meters.

The shallow rivers and lakes in the zone of perpetual frost freeze all the way down to the very bottom. In places where large amounts of deep-ground water force their way to the surface, immense ice fields and mounds, as well as hills, are formed. Such ice fields at times cover areas comprising hundreds of square kilometers and cause large areas of forest to perish. They also prevent the sprouting of seasonal agricultural plants, cutting even shorter the already brief growing season in these localities.

The lower ever-frozen layers obstruct the warming of the active soil and, hence, decrease the temperature of the stratum in which the root systems of cultivated plants spread. In these inadequately warmed strata microbiological activity lessens, and the process of nitrification and aerobic fixation of nitrogen is suppressed.

In the soils of light mechanical structure, it is necessary to add a large quantity of manure because of their scanty supply of nourishing substances for agricultural plants and the insufficient depth of tillable soil. Furthermore, owing to the feeble biochemical activity of these soils, it is necessary to add decomposed manure.

The best results come from a mixed manure with mineral fertilizers. The soils in most of these localities are of different kinds of podzol and marshy, sour soils that also require lime. The soils in the zone of perpetual frost are divided generally into two distinct groups: (i) "mineral soils" that have been formed in the process of decomposition of the rock deposits, and (ii) "organic soils" that have been formed as a result of the process of plant decomposition.

The subsoil rock under the "mineral

soils" is always found at a lower level than the "organic soils." However, in spite of all measures toward improving the water, air, and temperature conditions of the soils, the microbiological activity here remains most suppressed, and the sources of mineral nourishment for the plants are severely limited.

Usually, crops are best in the second year following the plowing of the new land, but after a year or so they catastrophically diminish, often failing to return even seed. Only by application of large amounts of organic, mostly manure, and mineral fertilizer can one maintain the subsequent crops on a more or less medium output level.

The peaty and peat-gley soils are more difficult to reclaim for agriculture because of the proximity of the ever-frozen layer (30 to 40 centimeters); this is true in spite of the presence of a high potential of fertility. Therefore, these areas must be dried, and the moss and peat must be burned. After this, perpetual frost will drop considerably, and the area can be used for the cultivation of agricultural plants, yielding adequate crops.

In the drouth areas of the zone of perpetual frost where the land can be dried, such as the central Yakutian region with its varying continental climate of between 195 and 235 millimeters of precipitation a year, agriculture stumbles into other difficulties. Although perpetual frost here is conducive to a certain degree to agriculture, with regard to the water supply of the soil and the influence on the economical evaporation by the plants, nevertheless, precipitation is not sufficient for the normal development of agricultural plants. Therefore, artificial watering of agricultural plants takes on importance as one of the main factors in the effort to grow them, particularly, in the solonetz and solonchak black soil.

Normal crops of agricultural plants cannot be achieved on the solonetz, solonchak, or the tiaga humus-poor soils without large amounts of organic manure and green-crop manuring. The solonetz and solonchak meadow black soils react quite favorably when gypsum is added.

Agricultural tools and machinery are best if they are of small dimensions, for then they are more suitable for the comparatively small areas here. The draft animals here are horses and cattle. Attempts to train deer as beasts of burden have had no success because of the weakness and wildness of these animals. Tractors of average power do not answer to the local conditions. It is necessary to have them in smaller sizes and of smaller power.

The best agricultural plants are of the precocious sorts, with the shortest growing period. Grain crops with a little longer growing period often are killed with the arrival of the first autumn frosts during the ripening period, particularly in the valleys and low-situated places.

Potatoes and vegetables are even grown in the remote north. Somewhat south of here, in the taiga belt, cereals are also cultivated. They are barley, oats, spring wheat, and spring rye. Farther to the south, in the belt of leafy woods, the variety increases with additional plants, such as buckwheat, millet, and peas. The assortment of vegetables increases at the expense of cucumbers and the like, which require a longer growing period and a greater amount of warmth. Under the most favorable conditions in the zone of perpetual frost, the greatest yield of cereals per hectare amounted to: wheat and rye, 15 to 17 centners; barley and oats, 19 to 23 centners; potatoes, 100 to 120 centners.

The northernmost places where attempts have been made to cultivate land and where potatoes, vegetables, and even melons are grown are Naryan-Mar, Narvik, Igarka, and the southern slopes of the dunes of the Arctic Ocean shores on the peninsula of Taymyr. But similar attempts in these localities could be regarded as something of a gamble.

In a foreword to every volume of its Philosophical Transactions, *the Royal Society of London specifically disclaims that the papers it publishes are authoritative. The ultimate responsibility for their accuracy rests not with the Society, but with the authors. Further, though the Society is consulted from time to time by the government, it never gives a corporate opinion on any subject. On the contrary, it asks certain of its Fellows to reply, and they give their answers as their own opinions. By its abnegation of authority the Royal Society sets an example to the world. No scientific body would have better claim to be regarded as authoritative, if such a claim were ever legitimate; but it denies the legitimacy of any such claim. Science can only prosper when there is a general understanding that the last word has never been said on any subject: there must be no dogma, for that would be an obstacle rather than a help to enquiring minds.*—JOHN R. BAKER, *Freedom and Authority in Scientific Publication* (Society for Freedom in Science, University Museum, Oxford, 1953).

News of Science

Advance Payments for Subscriptions

"Long term advance payments for subscriptions," an article in the 15 Oct. issue of the *Library Journal* by William H. Kurth of the Library of Congress, calls attention to the possibility of important administrative savings for the publishers of periodicals and journals and for subscription agencies and libraries, if the present annual payment-in-advance arrangement were replaced by a longer term payment schedule. The article stresses the enormous volume of expensive paper work now necessary, under the 1-year term, to expedite the movement of periodicals from publisher to library. It also emphasizes that the library is actually not a year-to-year purchaser of a modest number of periodicals and journals but rather a consumer of periodical literature on a regular continuing basis, suggesting the feasibility of a long-term payment plan.

The article indicates that a saving in administrative expenses of approximately 60 percent could be achieved if a 3-year advance-payment plan were adopted. This saving would extend to renewal notices, invoicing operations, recording of payments, and correspondence; the subscription agency and library counterparts of these operations would also be subject to the same reductions in costs. Under the proposed plan, more favorable subscription rates for libraries would be possible, and for the publisher there would be a longer term guaranteed circulation. (Of 2500 periodicals and journals listed in a national subscription agency's catalog, 65 percent now list rates for no more than a 1-year term and 21 percent offer no more than a 2-year term.)

Kurth points out that the primary impetus for establishing the 3-year term must come from the libraries; he suggests further that the development of the plan could be carried out by a special committee made up of representatives from publishers associations, subscription agencies, and library associations.

The article urges prompt adoption of the proposal and presents a schedule illustrating a procedure through which libraries, over a period of years, could change from a 1-year term to the 3-year one. The schedule outlines the orderly shifting of a uniform group of 1-year payments each year until the conversion is concluded.

Mellon Institute, 1954–55

During the past year the Mellon Institute's expenditures for pure and applied research amounted to $4,784,344. Of this sum $1,033,172 was spent in support of investigations in pure science in the institute's six research departments, and the remainder supported 12 fellowships. Altogether, 147 members of the institute were engaged in various pure science research projects.

The applied science research of the institute was conducted by 390 scientists and engineers who were employed by 64 other fellowships. On all the 76 fellowships there were 479 fellows and aides.

An electron microscope laboratory was added to the department of research in chemical physics and a division of microanalysis was formed in the department of analytical chemistry. A totally new department devoted to applied mathematics was established, and the facilities for microbiological research were expanded.

Pure research investigations were conducted in the following areas: vibrational analysis of trifluoromethyl acetylene, selection rules for ethanelike molecules having free internal rotation, temperature dependence of hydrogen bonding in hydrogen chloride-ether solutions, development of crystallinity in elastomers, crystal structure of antimony pentachloride, and instrumentation in x-ray diffraction. Also, studies of separation and purification were advanced.

In instrumentation, a new recording balance, a recording friction instrument, an automatic recording sward rocker, and automatic surface tension equipment were developed. Construction of the digital computer continued.

Other pure science researches were concerned with air pollution, pharmacological and toxicological problems, orthopedic appliances, fundamental problems in glass science, the synthesis of a new series of alicyclic hydrocarbons, the properties of synthetic elastomers, special resins and solvents for the care of paintings, the study and development of components employed in digital data-handling systems, and the importance of standards in government and the industries.

Eleven fellowships were initiated in 1954–55: aerosols, bituminous coal, carbon black, electronic printing, fatty alcohols, fiber glass, film properties, food packaging, information processing, life preservers and plate glass. Five fellowships completed their research programs: agglomeration, coal-waste control, fine wire and flat strip, garment filling materials, and thread.

Holders of continued applied science fellowships investigated problems in measuring fluid flow, in developing selenium power rectifiers, in improving structural clay products and castable refractories, and in metal forming techniques. Other projects were carried out in many other fields, embracing natural gas, petroleum, foods, insecticides, corn products, textiles, and paper. Work in synthetic organic chemistry was concerned with new and improved resins and organic coatings, silicones and medicinal preparations.

News Briefs

■ Secretary of Agriculture Ezra Taft Benson recently ordered that the security risk classification be removed from the USDA file on Wolf Ladejinsky, agricultural expert who was dismissed from the department last January. Ladejinsky had conducted outstanding land reform work in Japan during the occupation; after he had been suspended he was employed almost immediately by the Foreign Operations Administration (now the International Cooperation Administration) to act as an agricultural adviser in Vietnam.

At his own request, Benson appeared on 27 Sept. before a Senate subcommittee that is conducting an investigation of Government security procedures. In response to a subcommittee counsel's statement that it had been "gratuitous and unnecessary" to disqualify Ladejinsky on security grounds, Benson replied: "Yes, I think that is essentially correct." The Secretary of Agriculture stated further that he knew that the USDA had made mistakes in its administration of the security program "but they were honest and conscientious mistakes."

With regard to Agriculture's recently revised security procedure, he added: "I feel very good about the changes we've made, the committee we've set up and

the new procedures we've adopted. I feel we have made great progress in the last few months. We're in a position now to do a much better job than we were then. Certainly I am more experienced."

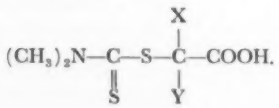
■ The following research projects were reported in the 13 Aug. issue of *Nature*.

W. J. C. Ross and G. P. Warwick, of the Chester Beatty Research Institute in London, have reported that the azo-mustards, substances that are inhibitory to tumor growth, can be chemically reduced and thereby made more effective by the enzyme system xanthine-oxidase + xanthine, which can be obtained from cow's milk. The mechanism of this reaction suggests that azo compounds reducible by xanthine oxidase should be particularly effective against neoplasms that are high in xanthine oxidase content, for example, hepatomas.

A comparative study of the contractile vacuoles of protozoans such as *Vorticella* and *Paramecium* with the Golgi apparatus of the simple sponge *Grantia*, and with the Golgi apparatus of mouse cells from the epithelium of the epididymis, indicates that these structures are homologous. According to a team composed of J. B. Gatenby of Trinity College, Dublin, and A. J. Dalton and M. D. Felix of the National Institutes of Health, Bethesda, Md., the golgi apparatus of the sponge cells and of the mouse cells consists of Golgi granules, a system of double membranes, and some large vacuoles. The contractile vacuoles of the protozoans studied show the same elements.

Norman I. Bishop and John D. Spikes of the University of Utah have reported that they now have evidence that the Hill reaction in photosynthesis ($H_2O \rightarrow 2H^+ + O_2$) is inhibited by cyanide, provided that no oxidant such as ferricyanide is present in the system.

A team of four Dutch scientists, G. J. M. van der Kerk, M. H. van Raalte, A. K. Sijpesteijn, and R. van der Veen, has found a new type of plant-growth-regulating substance. These are the dithiocarbamates, such as



To be active as a plant-growth regulator, either X or Y, or both, must be H atoms. Unlike other substances with growth-regulating activity, the dithiocarbamides possess no basal ring structure with a high surface activity. Their action is weak, being only 1 to 5 percent of that of indole-3-acetic acid in standard pea and *Avena* tests.

The record sensitivity in taste appears to have been set by a Malayan Negrito boy tested with phenylthiocarbamide by J. W. H. Lugg of the University of Malaya. The boy successfully discriminated between distilled water and the solution of the drug in repeated trials at a concentration of PTC of only $6.5 \times 10^{-8} M$, which is about 100 times as sensitive as the lowest response to quinine that appears to be accurate. It was estimated that only 8×10^9 molecules of PTC was required to stimulate the taste buds in this individual. Two other Malayan Negrito boys were almost as sensitive. On the other hand, two women of the same tribe could not taste even a solution 2^{18} times stronger.—B.G.

■ The establishment of the first skin bank in a civilian hospital was announced at the recent meeting in Atlantic City, N.J., of the American Society of Plastic and Reconstructive Surgery. In a report that described the grafting of skin from recently dead bodies, James Barrett Brown, Minot P. Fryer, and Thomas J. Zaydon of the Washington University School of Medicine, St. Louis, urged that skin banks be set up in hospitals throughout the country.

Stored postmortem homografts provide a temporary biological covering that lasts from 10 to 30 days, until the patient is well enough to have raw areas of his body covered with his own skin. Such grafts can save the lives of critically burned accident victims.

When stored at ordinary refrigerator temperature, postmortem skin can be used as long as 3 weeks after removal. It can be stored for periods ranging up to 6 months if other methods, some still in an experimental stage, are used. These additional methods include freezing at temperatures as low as −79°F, and freeze-drying, which allows the dried skin to be stored on a shelf at room temperature.

■ U.S. Representative to the United Nations Henry Cabot Lodge, Jr., has requested that an item entitled "Progress in developing international cooperation for the peaceful uses of atomic energy: reports of Governments" be placed on the agenda of this autumn's 10th regular session of the U.N. General Assembly. In an explanatory memorandum accompanying the request, Lodge pointed out that

"During the past year, historic steps have been taken to promote the peaceful uses of atomic energy for the benefit of all mankind. In addition to the international conference on the peaceful uses of atomic energy, significant progress has been made toward the establishment of an International Atomic Energy Agency. Moreover, international cooperation in this field has been advanced by various states through programs of cooperation in developing regional and national efforts to promote the peaceful uses of the atom. All of the foregoing programs affect the vital interests of Member States of the United Nations.

"In recognition of the interest demonstrated by the General Assembly in this field, the United States believes that Member States would appreciate the opportunity to be further informed of new developments."

■ A new blood group antigen belonging to the Rh system has been reported in the *Journal of the American Medical Association*. Called V, that being the initial of the patient in whom it was discovered at St. Luke's Hospital, New York, the antigen is common in Negroes and rare in white persons. It is inherited as a dominant Mendelian characteristic. Of 150 West Africans, 60 had V; of 168 New York Negroes, 45 had it; of 407 London whites, two had V; and of 444 New York whites, two had it.

The scientists who announced the find are Albert DeNatale, Amos Cahan, and James A. Jack of New York and Robert R. Race and Ruth Sanger of London, England. Blood samples were supplied by D. A. Cannon of Lagos, Nigeria; J. N. Marshal Chalmers of London; G. M. Edington and I. Sackey of Accra, Gold Coast.

■ In an address to the Gulf Coast Industrial Health Conference on 23 Sept., Cyril Comar of the Oak Ridge Institute of Nuclear Studies said that the U.S.S.R. is ahead of the United States in research on the effects of nuclear radiation. He commented that "The Iron Curtain scientists have concentrated on learning how much radiation a man can stand and what too much does to him. They seemed pretty open about what they've learned about the peacetime uses of the atomic reactor. We actually got some valuable information from them."

Comar was a member of the United States delegation to the recent conference in Geneva on the Peacetime Uses of Nuclear Energy.

■ The Peiping Government has notified the special committee of the International Geophysical Year, 1957–58, that it would like to participate in the world-wide program of basic scientific research. In replying, the executive officials of IGY are understood to have informed Peiping that it is welcome to take part in IGY on the same basis as other countries. Communist China would be the 41st participating country.

■ On 24 Sept. the U.S. Atomic Energy Commission announced that another Soviet nuclear explosion had occurred in recent days.

■ Britain's first independent commercial television station began transmitting on 22 Sept. from Croydon, near London. The site was chosen and cleared for the construction of the buildings and tower a little more than 6 months ago.

The 10-kilowatt vision transmitter and the 2.5-kilowatt sound transmitter are both laboratory prototypes. Two further transmitters of approximately the same power outputs will be installed in the near future. These will be standard production versions.

Scientists in the News

OTTO M. SMITH ended 32 years of service at Oklahoma A. and M. College on 30 Sept. Smith, emeritus head of chemistry and chemical engineering, has served as director of A. and M.'s Research Foundation since 1946. In the course of his 9-year directorship, 90 scientists have conducted research in A. and M. laboratories and 200 students have earned graduate degrees while serving as paid research assistants.

Projects that have been developed at the college have included work on radar triangulation systems for tracking rockets and missiles; basic research in biological, physical, and the social sciences; development of anticonvulsion drugs; establishment of a laboratory for the use of radioactive materials; and the development of methods which are related to the purifying of the products from nuclear reactors. Smith has been instrumental during the past 5 years in securing contracts and grants for the college that have totaled nearly $2 million. These contracts have been supported by the Army Ordnance Corps, the Office of Naval Research, the Air Force, the Atomic Energy Commission, and a number of American industrial organizations.

Smith received the B.S. degree in 1907 from Drury College, Springfield, Mo., and the M.S. and Ph.D. degrees from the University of Illinois in 1918 and 1919, respectively. He joined the faculty of Oklahoma A. and M. in 1923 as head of chemistry and chemical engineering, a post that he filled until his retirement in 1949.

Smith served as chairman of the Committee on Tests and Measurements of the American Chemical Society from 1930 to 1946. Under his leadership, the battery of tests for 4 years of college work in chemistry has been adopted on a worldwide scale. He has also been chairman of the Committee on Teaching of College Chemistry since 1946 and is credited with introducing the college teachers' Chemistry Institute. The idea, first put into practice at A. and M. in 1950, was used in three summer institutes in 1955.

Dr. and Mrs. Smith plan a trip to Brazil, where their son is a member of the electrical engineering faculty of the Instituto Technologico de Aeronautica at São Paulo. Smith was succeeded by MARION T. EDMISON, former associate professor of chemistry at the University of Arkansas.

At a meeting on 5 Oct. of the American Academy of Arts and Sciences, Cambridge, Mass., the academy's Amory prizes were presented. These awards of $3500 each are given for the invention or discovery of measures for the relief or cure of diseases affecting the genitourinary system. The recipients were:

FREDERIC E. B. FOLEY, Lowry Medical Arts Building, St. Paul, Minn., for development of contrivances, instruments, and operations of great value in the treatment of those afflicted with urological disease.

CHOH HAO LI, University of California, Berkeley, for his work on the relationship of the anterior pituitary hormones to the maintenance and functioning of the human reproductive organs.

THADDEUS R. R. MANN, Molteno Institute, University of Cambridge, Cambridge, England, for his basic contributions to the rapidly expanding field of the biochemistry of reproductive functions and for providing basic data that stimulate research and clinical progress.

TERENCE J. MILLIN, Queen's Gate Clinic, London, England, for devising and developing the technique of retropubic prostatectomy for benign hyperplasia of the prostate and for adapting this technique to radical prostatectomy and vesiculectomy for the cure of cancer of the prostate.

WARREN O. NELSON, State University of Iowa College of Medicine, for his studies of the structural relationships of the male sex organs and of the factors that determine the functional activities of the various components thereof.

FREDERICK J. WALLACE, American Cystoscope Makers, Inc., New York, N.Y., for his cooperation with the urological profession in developing diagnostic and therapeutic instruments that have contributed materially to the technical advances in this specialty.

LAWSON WILKINS, John Hopkins University, in recognition of his contributions to fundamental knowledge of growth and development of secondary sex characteristics in man and his brilliant application of adrenal cortical hormone to their management and treatment.

A. R. DAVIS, plant physiologist and for 8 years dean of the College of Letters and Science at the University of California, Berkeley, became vice chancellor of the Berkeley branch of the university on 1 July.

ROB ROY MCGREGOR, author of *Silicones and Their Uses,* has joined the research staff of the Dow Corning Corp., Midland, Mich., as research administrative assistant. He will direct his attention to silicone applications in the medical and biological fields.

Since 1942 McGregor, one of the pioneer research workers in silicone chemistry, has worked with Dow Corning through the Mellon Institute, Pittsburgh, Pa., where he was administrative fellow of the Corning Glass Works–Dow Corning Corp. fellowship.

ALVIN M. WEINBERG has been appointed director of Oak Ridge National Laboratory. Weinberg, who formerly was research director of the laboratory, assumed his new post on 1 Oct. 1955.

EDWARD B. TRUITT, JR., has resigned as assistant professor of pharmacology and as A. H. Robins Co. fellow in pharmacology at the Bowman Gray School of Medicine of Wake Forest College, Winston-Salem, N.C., to assume the position of associate professor of pharmacology at the University of Maryland School of Medicine, Baltimore.

THEODORE C. BYERLY has been appointed assistant director of livestock research in the Agricultural Research Service of the U.S. Department of Agriculture. NED R. ELLIS, former head of the meat production and evaluation section, has succeeded Byerly as chief of the ARS Animal and Poultry Husbandry Research Branch.

In his new position, Byerly will assist B. T. SIMMS, who became director of livestock research following the retirement of OLLIE E. REED on 1 Sept. Simms was formerly head of the animal disease and parasite research branch, of which HOWARD W. JOHNSON is now the acting head.

DAVID R. GODDARD of the University of Pennsylvania is visiting the department of botany at the University of Washington, Seattle, during the fall quarter. He is giving a series of lectures on cellular metabolism under the auspices of the Walker-Ames professorship.

HAROLD S. OLCOTT, food specialist of the Western Regional Research Laboratory, U.S. Department of Agriculture, has been appointed professor of marine food technology and marine food technologist on the staff of the University of California's state-wide Institute of Marine Resources. Although the institute has headquarters at La Jolla, Olcott will be associated with the department of food technology at Berkeley, where he will direct research work leading toward advanced degrees in food science and comparative biochemistry.

RICHARD C. TROUTMAN, assistant professor of ophthalmologic surgery at Cornell Medical Center, has been named to the joint post of professor of ophthalmology at the State University College of Medicine in Brooklyn and director of ophthalmology at the Kings County Hospital, both on a part-time basis.

H. WALDO BIRD, practicing psychiatrist of Detroit, Mich., and former faculty member of Wayne University, has been appointed associate professor of psychiatry at the University of Chicago School of Medicine.

V. N. BRUCE, an engineer and the vice principal of a high school in Ottawa, Canada, has joined a teacher training mission in Burma as a specialist in science teaching. Under the United Nations Educational, Scientific and Cultural Organization's program of technical assistance, Bruce will assist the Burmese authorities in improving existing facilities and in training local science masters.

Burma has undertaken the extension of free schooling throughout the country. The plan involves the building of 6000 schools and the training of teachers to staff them. A large majority of the schools are in rural areas. The UNESCO teacher training mission has prepared a booklet on elementary science and also portable laboratories of suitcase size. An important part of Bruce's mission will be to develop suitable equipment at small cost.

MAX E. BRITTON, plant ecologist, has resigned from the faculty of Northwestern University to assume administrative direction of the arctic research program of the geography branch of the Office of Naval Research, Washington, D.C.

HERMAN F. MARK, chemist and director of the Institute of Polymer Research, Polytechnic Institute of Brooklyn, was honored by several European universities and professional groups during the summer. He received a medal and honorary membership from the University of Vienna, the dégree of honorary professor from the Technical University of Berlin, and the Trasenster medal of the Association of Belgian Engineers.

OLIVER LOWRY, professor of pharmacology and head of the department in the Washington University School of Medicine since 1947, has been named dean of the School of Medicine. Lowry, whose appointment is effective immediately, will continue in his posts in the department of pharmacology. He succeeds CARL V. MOORE, who resigned in June to devote his time to research and teaching.

WALTER G. DRISCOLL, formerly of the U. S. Department of Defense, has been appointed assistant director of research at Baird Associates, Inc., Cambridge, Mass., manufacturers of precision instruments.

JACOB DAVID GOLDSTEIN, associate professor in medicine and in bacteriology at the University of Rochester Medical School, has been named to the joint post of professor of medicine at the State University of New York College of Medicine in Brooklyn and chief of medicine at the Jewish Hospital of Brooklyn, effective 1 Nov. This appointment is part of the recent affiliation between the college's department of medicine and the hospital's medical service.

The following appointments to assistant professor have been announced. West Virginia University: LEROY HALLOWELL SAXE, JR., pharmacology; JOHN BARKER HARLEY, pathology. Park College: ERWIN RUBINGTON, sociology.

The following appointments to assistant professor have been announced. California Institute of Technology: CLARENCE R. ALLEN, LEON T. SILVER, and GERALD J. WASSERBURG, geology; ROY GOULD and ROBERT D. MIDDLEBROOK, electrical engineering. University of Connecticut: ARNOLD RUSSEK, physics.

Necrology

CHARLES T. GRAHAM-ROGERS, Ridgefield, Conn.; 81; toxicologist; for 37 years expert on poisons for New York State Department of Labor; 24 Sept.

NOBLE S. HEANEY, Beverly Hills, Calif.; 75; emeritus professor of obstetrics and gynecology at Rush Medical College, Chicago, Ill.; 26 Sept.

LOUIS A. HELD, Brooklyn, N.Y.; 62; radiologist; former instructor in diagnostic radiology and therapy at New York Post-Graduate Hospital; 20 Sept.

ALFRED F. HUETTNER, Douglaston, N.Y.; 73; emeritus professor of biology and former chairman of the department at Queens College, Flushing, N.Y.; 27 Sept.

BERTRAM LOW-BEER, San Rafael, Calif.; 54; radiologist; pioneer in the use of radioactive isotopes in diagnosis and treatment of cancer, expert on therapeutic use of radiation, professor at the University of California Medical School in San Francisco; 25 Sept.

ADOLPH MACHLET, Elizabeth, N.J.; 90; metallurgist and inventor; 27 Sept.

WALTER D. SCOTT, Evanston, Ill.; 86; psychologist, educator; pioneer in applying psychology to business, first professor of applied psychology in the United States, president emeritus of Northwestern University; 23 Sept.

Education

■ The William Goldman Laboratory of Microscopic Anatomy at Hahnemann Medical College and Hospital was dedicated on 29 Sept. One of the participants in the ceremony, in addition to the donor, William Goldman, president of Goldman Theaters, Inc., was Charles L. Brown, dean of Seton Hall University School of Medicine and formerly dean at Hahnemann.

■ The new $1,580,000 Renard Hospital, psychiatric unit of Washington University–Barnes Medical Center (St. Louis), was dedicated on 10 Oct. Presiding at the dedication were Ethan A. H. Shepley, chancellor of Washington University, and Louis Renard, son of the late Mr. and Mrs. Wallace Renard who contributed funds for the construction of the hospital.

Speakers for the ceremony included Arthur H. Compton, distinguished service professor at Washington University; Alan Gregg, vice president of the Rockefeller Foundation; and Philip A. Shaffer, distinguished service professor emeritus and lecturer in biological chemistry and a former dean of Washington University School of Medicine.

A 2-day scientific symposium on "Newer aspects of the theory, etiology and treatment of the psychoses" was held in conjunction with the dedication. Participants were Stanley Cobb, Alfred H. Stanton, George Saslow, and B. F. Skinner, all of Harvard University; John C. Whitehorn of Johns Hopkins University; and F. C. Redlich of Yale University.

■ Columbia University School of Engineering has acquired a steel radio antenna tower and brick laboratory building from the estate of the late Maj. Edwin H. Armstrong, inventor of FM radio and long a professor of electrical engineering at Columbia. The installation, which is situated on the west bank of the Hudson River near Alpine, N.J., will be known as the Edwin H. Armstrong Field Laboratory and will be used by the department of electrical engineering for research in radiation and propagation of various types of radio waves, particularly with respect to their behavior in the atmosphere, ionosphere, and upper atmosphere.

In addition to the Alpine site, Columbia also has acquired from the Armstrong estate 57 acres of land in the towns of Catskill and Hunter, N.Y., an area that includes one of the higher peaks in the Catskill Mountains. These two sites, together with Columbia's engineering camp near Litchfield, Conn., will form a triangular range for extensive field studies in radar and radio.

Grants, Fellowships, and Awards

■ Rumford Fund grants for research in heat and light, including thermodynamics and radiation of any frequency, may be applied for from the Chairman, Rumford Fund Committee, American Academy of Arts and Sciences, 77 Massachusetts Ave., Cambridge 39, Mass. Awards do not usually exceed $1000.

Applications must outline the nature and significance of the proposed project, the plan of procedure, the investigator's background and his recent publications bearing on the subject, and how the grant would be used specifically. *Applications should be filed before 1 Jan.*

■ The Scholarship and Student Loan Fund Committee of the Special Libraries Association has announced that two $500 scholarships are to be granted for the academic year 1956–57 for graduate study leading to a degree at an accredited library school. Applicants must be college graduates of high academic achievement who need financial assistance in obtaining the professional education necessary for work in the special library field. Application blanks and details of eligibility for the awards may be obtained from the Executive Secretary, Special Libraries Association, 31 E. 10 St., New York 3. *Applications must be received by 1 Mar. 1956.*

■ Establishment of an annual award of $1000 and a medal for outstanding achievement in industrial and engineering chemistry was announced at the recent meeting of the American Chemical Society in Minneapolis, Minn. The award, which is to be given by the Esso Research and Engineering Co. (formerly the Standard Oil Development Co.), has been established "to stimulate fundamental research in industrial and engineering chemistry and in the development and application of chemical engineering principles to industrial processes."

■ The University of Michigan has received a grant of $100,000 from the Ford Motor Company Fund for fundamental research in soil-plant relationships. A project entitled the Ford Agricultural Plant Nutrition Project has been established in the department of botany and botanical gardens under the direction of A. G. Norman, who will be assisted by a staff of predoctoral and postdoctoral students.

■ The University of Wisconsin has announced that a research assistantship to provide training in science writing will be available for an outstanding graduate student in February 1956. Applicants should have a background of several sciences and journalistic training or experience, or a demonstrated ability and aptitude; they should also intend to take up science writing as a career. The research assistant, who will receive a stipend of $1560 for the year, may work for an advanced degree in any field.

■ The Committee on Growth of the National Academy of Sciences–National Research Council invites applications for grants for scholars in cancer research that are offered by the American Cancer Society. The purpose of these grants is to assist institutions in the support of young scientists during the early period of their careers as independent investigators. Grants are awarded for 3 years at $6000 per year, with renewal for 2 additional years unless there are compelling reasons to the contrary.

Applications should be submitted by institutions on behalf of candidates *not later than 1 Jan. 1956.* Application blanks may be obtained from the Committee on Growth, NAS-NRC, 2101 Constitution Ave. NW, Washington 25.

In the Laboratories

■ Atomic Energy of Canada Limited has announced that the NRX reactor at Chalk River has gone back into operation after a 7-week shutdown. A special fuel rod that was being tested damaged an aluminum tube in the reactor tank, contaminating the heavy-water moderator and sprinkling small chips of plutonium fuel on the bottom of the tank. Automatic devices shut down the reactor immediately; the main operating room was not contaminated.

This breakdown was in no way comparable to the breakdown of 12 Dec. 1952, when a power surge damaged several fuel rods so that the reactor had to be extensively decontaminated and reconstructed. Additional safety devices were built into the reactor during the reconstruction, and modification made it possible to operate the reactor at a heat output of 40,000 kilowatts, 33 percent higher than was possible before the reconstruction. The new safety devices performed as planned when the test fuel rod failed.

While extensive damage was not experienced in the recent shutdown, the decision to speed the repair job by carrying out the work without dismantling the reactor made operations difficult. Thick concrete and steel shields above the reactor tank, which weigh up to 19 tons each, made it necessary to carry out repairs from a considerable distance. Some idea of the difficulty of the repair operation may be gained from the fact that skilled workmen were restricted to working through a 2½-inch hole at distances up to 28 feet from the damaged part of the reactor.

Chips of plutonium fuel resting on the inside bottom of the reactor tank had to be removed before the repair work could proceed. When ordinary water failed to wash the chips away, 6000 gallons of soda water were run through the tank. Gas bubbles from the soda water formed on the fragments and lifted them off the tank bottom, thus allowing them to be flushed out.

■ A library of noise will be one of the major results of a new sound analysis laboratory recently completed by the General Electric Company at Fort Wayne, Ind. Recordings of the slightest murmur of electrical transformers and motors will be collected in the library; these recordings will be used to compare various noises, so that noise sources can be isolated and corrected.

The sound room has an ambient noise level of plus 10 decibels. This free field (anechoic) chamber exceeds the testing specifications recommended by the National Electrical Manufacturers Association. It will be possible to make sound analyses on units whose acoustical power ranges from 10^1 watts to 10^9 watts. All tests are conducted by remote control, for the human body reflects a certain amount of sound and is incapable of remaining absolutely motionless and silent.

The laboratory building is constructed so that its walls are not parallel to any nearby structure. This prevents outside noises from reflecting back and forth between the laboratory and other buildings, and also prevents the subsequent build-up of sound energy from outside walls.

The testing chamber, literally a 500,000-pound room within a room, floats on steel springs and rubber shock absorbers to help prevent transmission of ground vibration such as would be caused by a passing train, for example. To further isolate the room, its walls are of 8-inch concrete, lined with 3 inches of flat mineral fiber acoustic batting. Over this layer is another 3 inches of the same material, which covers the entire inner surface of the room.

A steel ramp extends from the doorway of the chamber into the exact center of the room, where equipment to be tested is placed. Microphones and instruments are suspended above the ramp; they are connected to recording equipment outside the room.

■ The Upjohn Company, Kalamazoo, Mich., has announced formation of a Mexican subsidiary, Upjohn de Mexico S. A. de C. V., which is expected to begin operations by 1 Dec. This is the fourth firm that Upjohn has set up abroad.

Reports and Letters

Specimens from Sandia Cave and Their Possible Significance

During periods of the years 1936, 1937, 1938, 1939, and 1940 a cave in the Sandia Mountains near Albuquerque, N.M., was excavated for such evidences of early occupation as it might contain (*1*). This cave, called the Sandia cave, became chiefly notable because one layer within its deposits was identified as Folsom in date and contemporaneous with Folsom campsites at such places as Clovis, N.M. (*2*), and Lindenmeier, Colo. (*3*). Below the Folsom level of Sandia Cave occurred another stratum of human occupation called the Sandia level. Because of its subposition, the Sandia culture, contained in this level, gave promise of being even earlier in date than the Folsom level above, which had previously represented the earliest demonstrable occupation of North America.

In 1948 two specimens of charcoal from fire hearths of the Sandia level of Sandia Cave were submitted by Kirk Bryan of Harvard University to W. F. Libby of the University of Chicago for C^{14} dating. At that time the technique of radioactive dating was in its infancy, and a copious specimen was necessary. From these two samples, tentative dates of 17,000-plus years ago and 20,000-plus years ago, respectively, were derived.

Bryan was emphatic that these dates should not be published at the time, because of the inadequacy of the samples and the possibility of a considerable error. Unfortunately, no additional charcoal had been saved from the Sandia excavation for further testing.

Recent runs of ivory material from the same Sandia level tested by H. R. Crane at the University of Michigan have tended to corroborate the earlier dating and have given a more exact determination of the probable time of the first Sandia Cave occupation.

Specimen No. 1 submitted to the Michigan laboratory was derived from the Sandia level of the cave near meter No. 8 from the entrance. This specimen is apparently mammoth ivory and represents a fragment near the point of a large tusk.

The second specimen submitted to the Michigan laboratory is probably from a different tusk, since it occurred near meter No. 17, well within the cave. This fragment was associated with two long bones that have been identified as those of a mastodon and so may represent a piece of ivory from that mammal.

It may be mentioned that both mammoth and mastodon occurred in the Sandia level of Sandia Cave. Many bony splinters were representative of these two kinds of elephants, with the mammoth definitely in the majority. Butchering techniques apparently included the bringing back of large segments of these animals to the cave. The meat was cut from the bones, as is indicated by occasional scars on the bone surfaces. Subsequently the bones were cracked and broken lengthwise to extract the marrow. Many bone fragments had been so thoroughly broken in this manner that they were identifiable only as those of some elephant.

More difficult to explain was the presence of both tusks and teeth in the cave assemblage. It would seem that at least occasionally the Sandia hunters brought back to the cave portions of the heads and skulls of these ponderous animals. The ivory may have served as material from which tools and weapons were manufactured, although none such were actually found in the Sandia level. In the Folsom level above, a pointed ivory implement was recovered. At the Clovis Site at Clovis, N.M., ivory foreshafts were found associated with the Clovis variation of the Folsom culture.

The mammoth and occasional mastodon teeth in the Sandia Cave are more difficult to explain, since these were apparently never used and would appear to be useless impedimenta to the prehistoric hunters. It is interesting to note that mammoth teeth occur very commonly at the Clovis Site and also are present at the Sandia level of another site that has been recently excavated near Lucy, N.M. We may only suppose that these ancient hunters dragged back elephant skulls to their camping places to cut out the brains or such fragments of flesh as might adhere to the bones.

Although carnivores of the late Wisconsin period undoubtedly laired in the Sandia Cave intermittently with human occupation, it seems improbable that fragments of ivory and teeth would be attributable to these mammals. Meat-eating animals would scarcely be expected to carry portions of elephants' skulls from the place of the kill into the cave.

We are forced to conclude, therefore, that human beings brought into the cave the elephant ivory specimens that the Michigan laboratory has dated. Because of the split long bones of both mammoth and mastodon present at the Sandia level, it seems patent as well that the Sandia hunters killed both of these varieties of elephants and brought portions of the kills back to the cave. There have been suggestions in other early sites that perhaps the Paleo-Indian acted as an antiquarian at times. If the Sandia hunters had brought back to the cave fragments of tusks of some older, already fossilized specimens, the dating of these specimens would be of little value. In the case of the elephant ivory recently dated, there is every evidence that these were fresh kills and contemporaneous with the time of the human occupation with which they were found.

In addition to the aforementioned evidence that the C^{14} dates revealed by Crane's measurements actually represent a true chronology of the Sandia hunter culture, there is further corroboration. In the Sandia Cave there was a definite sequence of wet and dry strata with associated human occupation levels corresponding to the dry periods. The topmost level of the Sandia Cave is a dry accumulation of recent origin. Archeological finds associated with this level are Pueblo an in date and represent sporadic occupations of only the last few centuries. Beneath this uppermost, recent level lies a layer of calcium carbonate in the form of a crust definitely deposited under wet conditions.

Beneath the calcium carbonate crust lies the Folsom cultural level of the cave. Cultural materials from this occupational level are typically Folsom in nature and close to the classic variety of the original Folsom Site, or the Folsom camp at Lindenmeier, Colo. Although no definite fire hearths are found in this Folsom level, enough charcoal was derived from the debris for a single inadequate C^{14} run at the University of Chicago Institute for Nuclear studies. This run seemed to indicate a comparable antiquity with the Folsom camp near Lubbock, Tex., which yielded a C^{14} date of 9883 years before the present with a possible error of 350 years. It must be emphasized, however, that the C^{14} dating of the Folsom level of Sandia Cave was inadequate and the co-relation of this Folsom material with other cultures of the same variety has been done for the most part on typological grounds. This Folsom level represents a dry period of the cave when human occupation was possible.

Below the Folsom occupation stratum

is a sterile level of yellow ochre that is laminated and water-laid. This represents a period when human occupation was undesirable or at least not present.

The Sandia cultural level lies below the yellow ochre level and again represents a dry period. Two charcoal lenses or fire hearths were found in the Sandia level, and it was from these that the original C^{14} datings were made. The cultural material of the Sandia level is, of course, distinct and earlier by its very subposition beneath the Folsom stratum and the superimposed yellow ochre. Below the Sandia level is a sterile layer of clay representative of another wet period immediately following the formation of the cave itself in the Pennsylvania limestone.

Bryan was able to relate the wet and dry sequences in the Sandia Cave with exterior glacial happenings in the vicinity. On this evidence he was able to postulate that the Sandia People may have entered North America in the pre-Mankato interstadial or, as it is called in the Colorado-New Mexico area, the pre-Corral Creek or W_2-W_3 interstadial (*4*). From this evidence Bryan argued that Sandia hunters may have occupied Sandia Cave as early as 25,000 years before the present day. Bryan made this estimate before any C^{14} dates were available. Unfortunately, his untimely death prevented his ever knowing that his estimate had been remarkably accurate.

The geologic correlation of the wet and dry levels of the Sandia Cave seems to corroborate the evidence of archeological stratigraphy. The C^{14} dates recently measured by Crane logically fit in with a pattern already established by other data. We may only assume that human beings such as those who left the Sandia culture as evidence of their presence were already established in the American Southwest at least 25,000 years before our time.

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References

1. F. C. Hibben, *Evidences of Early Occupation in Sandia Cave, New Mexico, and Other Sites in the Sandia-Manzano Region*, Smithsonian Misc. Coll., vol. 99, No. 23 (1941).
2. F. H. H. Roberts, Jr., *A Folsom Complex: Preliminary Report on Investigations at the Lindenmeier Site in Northern Colorado*. Smithsonian Misc. Coll., vol. 94, No. 4 (1935); *Additional Information on the Folsom Complex Report on the Second Season's Investigations at the Lindenmeier Site in Northern Colorado*. Smithsonian Misc. Coll., vol. 95, No. 10 (1936).
3. E. B. Howard, *Evidence of early man in North America, Museum J. Univ. of Pennsylvania*, 24, No. 2–3, 61 (1935).
4. K. Bryan and L. L. Ray, *Geologic Antiquity of the Lindenmeier Site in Colorado*. Smithsonian Misc. Coll., vol. 99, No. 2 (1940); L. L. Ray, "Glacial chronology in the southern Rocky Mountains," *Bull. Geol. Soc. Amer.* 51, No. 12, pt. 1, 1851 (1940).

22 March 1955

Antiquity of the Sandia Culture: Carbon-14 Measurements

In 1952 Frank Hibben of the University of New Mexico submitted to us two fragments of mammoth tusk that came from the Sandia level of Sandia Cave in New Mexico in association with evidence of human habitation. In 1954 he submitted a third fragment. The Sandia level at which the tusk fragments were found was below the Folsom level of the cave. The Folsom level had been dated by C^{14} on a previous and inadequate sample of ivory fragments at about 11,000 years. The figure of about 11,000 years has so far seemed to represent, in American anthropology, a rather sharp cutoff beyond which little is known. Sandia material, therefore, occupies a position of unusual importance, and it will be of great interest to investigate thoroughly every bit of available material and to make available the results in detail. Our C^{14} measurements on the tusk material are presented here (*1*).

The radiocarbon dating method used at the University of Michigan employs a Geiger counter into which a gaseous, CO_2 sample is introduced. The method has the advantage, for the present investigation, that the amount of carbon sample required is very much smaller than that required in the method that employs a solid carbon sample. Only about 700 mg of carbon in the form of CO_2 are required to fill the counter, and a sample of raw material containing 2 g of carbon is usually sufficient (In our previous work, using carbon black samples, we required about 100 g of raw material.) The small weight of carbon that suffices for the present method made it possible to prepare, from the available Sandia tusk material, sufficiently large samples of CO_2 that were derived entirely from the *organic* (*2*) constituents of the tusk. This was a safeguard against the most likely source of extraneous carbon, namely, water-deposited carbonates.

The method of preparation of a CO_2 sample from the tusk material was, briefly, as follows. The tusk was broken up into small bits and heated in a closed iron vessel to a dull-red heat, in order to carbonize (char) the organic constituents. It was then treated with dilute hydrochloric acid to dissolve the carbonates and other acid-soluble compounds. After this treatment, finely divided carbon black remained, which was then washed and dried. The weight of the carbon residue was about 7 percent of the weight of the tusk material. The carbon was then burned to CO_2, and the CO_2 was purified in the usual way, which consists of absorption in ammonia, precipitation as $CaCO_3$, washing and re-evolution by HCl.

The tusk material received in 1952 was carried through the chemical process in two batches, each yielding enough CO_2 for two counter runs. The first two runs were compared with runs that had been made, both before and afterward, on tank CO_2, which had been standardized against CO_2 made from lampblack (petroleum origin) according to our standard procedure of preparation.

After carefully assessing the degree of consistency in the results that we had been obtaining, over a period of several months, on many different counter fillings of CO_2 of identical origin (both the tank CO_2 and the modern wood CO_2 were used) and other factors, we were confident in saying that the Sandia tusk was *at least* 20,000 years old. Actually, the counting rate obtained from the Sandia sample was the same as the average of the counting rates obtained from petroleum carbon, so the 20,000-year figure was merely a limit that expressed, conservatively, the limits of error.

The CO_2 from the second batch of the 1952 material was used in a new series of runs. In these runs the comparison was made directly against CO_2 samples prepared from dead carbon, and special care was taken to prepare and handle all the samples, both the dead carbon and the Sandia material, in exactly the same way. In this way the intermediate step of comparison with tank CO_2 was elimi-

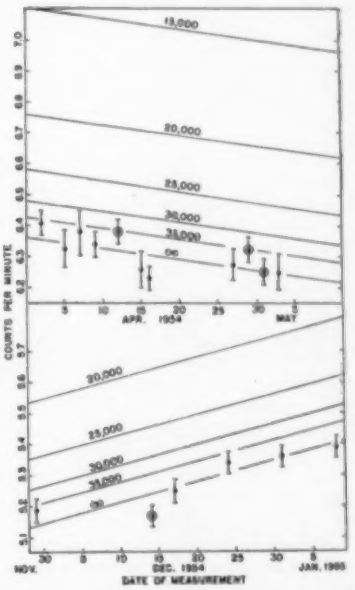

Fig. 1. C^{14} measurements on tusk material from the Sandia level compared with a number of measurements on samples of dead carbon. The Sandia measurements are identified by circles. The sloping lines correspond to the ages indicated. The vertical line through each point represents the standard deviation, based on the number of counts alone.

nated. For dead carbon, all but one of the samples was made by burning lampblack. One was made from tank CO_2, precipitated as $CaCO_3$ and carried through the usual purification process.

The results of the runs on the second batch of CO_2 are shown in the upper part of Fig. 1. Each run is indicated in its proper place on the day-of-the-month scale, and the standard deviation is shown. The gap between 17 and 26 April represents a period when the apparatus was shut down, because I was out of town. Smaller groups represent times when other samples, unrelated to the Sandia material, were run. They are not plotted, since they have no connection with the problem at hand. The line marked ∞ is an estimate of the "infinite age" counting rate, on the basis of the calibration runs shown. Its slope is caused by the gradual drift in the background counting rate over the period of more than a month. Such a drift is usual. Lines are shown that represent the counting rates for other ages, as labeled. Zero age would be 5 counts/min above "infinite" age. The Sandia samples are indicated by circles. The one on 12 April is a 48-hr run. The ones on 29 April and 1 May are two successive 48-hr runs on the same counter filling.

In the lower part of Fig. 1 is shown the result for the tusk material received in 1954. On the basis of all the runs made on the tusk material, we can say that there appears to be no significant difference in counting rate between the Sandia samples and the control samples of dead CO_2, when the statistical limits and the degree of consistency between runs are considered. With regard to the lower limit that can be placed on the age, the diagram speaks for itself. Twenty-five thousand years would certainly be a very conservative lower limit. A lower limit of 30,000 years would be consistent with the usual practice in assessing limits of error.

The great age of the Sandia tusk naturally raises the question whether it is contemporary with the evidences of habitation among which it was found, or whether, instead, we have discovered that among the men who inhabited the cave there were archeologists who collected and brought home tusks belonging to earlier times. Although the probability that such an explanation is correct is small, it nevertheless emphasizes the need for C^{14} measurements on other material from the same level.

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Notes

1. This work was supported by the Michigan Memorial Phoenix Project.

2. The remains from the protein materials, such as blood, as distinguished from the simple, acid-soluble compounds, such as the carbonates and the phosphates.

11 March 1955

Consensual Pupillary Response in Birds

Although the consensual reflex has been reported by Noll (*1*) to occur in birds, the behavior of the two pupils upon the stimulation of one eye with light is so markedly different that the question arises whether the apparent consensual contraction is a true reflex. In the typical consensual reflex of mammals, a beam of light directed into one eye causes the pupils of both eyes to contract simultaneously, and the contractions are equal in amount and duration. In the bird, on the contrary, the pupil of the stimulated eye contracts more promptly and with a greater contraction than does the pupil of the nonstimulated eye. Furthermore, the contraction of the pupil of the nonstimulated eye is capricious. It appears irregularly and varies in intensity and duration, and it is independent of the reaction of the pupil of the stimulated eye. Consequently, it is evident that if this slight, often momentary, reaction of the contralateral eye is a consensual pupillary reflex, it is markedly different from that of man and of other mammals.

The possibility that this small variable contraction of the pupil of the nonstimulated eye of the bird is not a reflex mechanism at all, but is instead a response to direct stimulation of the light, was suggested by some observations on pigeons. If one flashes an ordinary two-cell pencil flashlight into one eye of the pigeon so that the beam of light strikes the eye along the optic axis, the light will pass through the head of the bird and through the opposite eye. The pupil of the opposite eye will be illuminated to an intensity that is clear and unmistakable. A dissection of the head of the pigeon reveals that there is less than 1 millimeter of transparent bone and tissue between the two optic orbits. A beam of light can readily pass through this thin structure that intervenes between the two eyes. (Detailed microscopic drawings of these structures are given in Chard and Gundlach, *2*.)

As a result of this illumination from the rear, the retina is subject to direct stimulation. When this occurs, the pupil of the nonstimulated eye contracts. Since the light is greatly reduced in intensity because of the passage through the head, the contraction is necessarily smaller than that of the pupil of the eye upon which the light directly impinges. If the beam of light enters the first eye at too great an angle to pass through the head and strike the eye on the other side, then there is no consensual contraction. The observed variability in duration of the consensual reaction is then the result of a shift in the direction of the beam of light. In other words, what has appeared to be a consensual pupillary reflex in the bird is, in fact, nothing but the reaction of the pupil to the direct stimulation of light passing through the head.

Additional support for this conclusion has been obtained from observations on the owl. The visual axes of the owl are nearly parallel, and the projection of a beam of light directly upon one eye does not permit the light to pass through the head in the direction of the opposite eye. No consensual pupillary contraction whatsoever can be seen in the owl.

On the basis of these findings some evidence is now available that indicates that there is a functional, as well as an anatomic, difference between the visual systems of the bird and the mammal. As expected, the evidence shows a greater independence of function between the two eyes of the bird than there is between the two eyes of the mammal.

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References and Notes

1. A. Noll, *Pflügers Arch. ges. Physiol.* **182**, 350 (1915); *ibid.* **196**, 629 (1922).
2. R. D. Chard and R. H. Gundlach, The structure of the eye of the homing pigeon. *J. Comp. Psychol.* **25**, 249 (1938).

6 June 1955

Our Upper Colorado River Project

Paul B. Sears expresses the opinion that, in regard to the much discussed Upper Colorado Irrigation Development (and evidently the Echo Park Dam) "the remedy is simple . . . such aspects of major problems (should) be referred to competent boards of scientists" [*Science* **121**, 5A (29 Apr. 1955)].

Perhaps too many people—scientists included—have the feeling that the Echo Park Dam is the major point of contention in this controversy. Certainly everyone should know that California has a high-powered, well-financed committee whose main job is to prevent any irrigation development on the Colorado River above Lake Mead. This committee has been successful in persuading the nature lovers of the nation to oppose the Upper Colorado River projects, paying no attention to the promise of federal authorities to the people of that region that a storage project would be permitted when the Dinosaur Monument was extended in area. Thousands who have not seen Dinosaur National Park have responded

to the plea to "Save Our National Parks" by urging their Senators and Congressmen to oppose the Upper Basin Project. The fact that the proposed dam is above the dinosaur "burial ground" and that the reservoir would enable thousands to see the grandeur of the canyon, instead of the few who see it now, seems to have no effect upon the "saviors" of our national parks who give westerners, the people who know our parks and are most eager for their protection and proper use, no credit for not wanting them spoiled.

California does not tell these nature lovers about the Colorado River Compact, which assigns to the Lower Basin States a fixed amount of 7.5 million acre-feet of water annually—not 50 percent of the current flow—and makes the Upper Basin assume the shortage, if any, that, without storage, the Upper Basin must absorb in low water years. Obviously farmers and townspeople in the Upper Basin will look with disfavor and distrust upon any scheme decided by "experts" to appropriate most of the water that *originates* on their lands for the use of those on the farms and in the cities of California. Opposed to such "experts" are some of the best irrigation engineers in the world, U.S. Bureau of Reclamation engineers, and others who have examined and recommended the locations for dams and reservoirs.

There is no doubt of the sincerity of the wildlife conservationists, but the complete conservation picture should be presented to the public, and the water rights of the people of the upper states should be protected. This does not necessarily mean the loss of an area of great importance in a national park.

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13 June 1955

A. D. Moinat renders a service in pointing out the basic conflict of regional interests involved in the Upper Colorado problem—a complication, but by no means the only one, that may be unfamiliar to many whose attention is fixed on the single Dinosaur National Monument issue.

My communication to which he refers was actually concerned with more elementary aspects of this and other problems of policy, namely, the physical and biological facts that are amenable to scientific study. I do not for a moment propose that scientists take over the normal legal and political operations whereby policies are determined. I am trying only to urge that those whose business it is to shape policy do not work blindly or in willful disregard of cold facts. Charge and countercharge, claim and counterclaim are not substitutes for competent studies in field and laboratory.

If the advantage of having the scientific facts in hand when large public issues are being settled is not self-evident, surely the benefits that scientists have conferred upon our civilization entitle them to contribute, within the field of their special competence, toward the solution of such issues.

Incidentally, I have avoided taking either side of the Upper Colorado issue, although quotations from my writings have been used as ammunition and, doubtless, as targets. I do not have sufficient firsthand information to judge the relative merits of the contending parties. What I am insisting on is a more rational approach to costly public enterprises. First get the facts, then hammer out the solution. Such a program can injure no one, except those on shaky ground. Given all the facts possible, policy-makers need not fear that they will ever be faced with technologic unemployment.

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21 July 1955

"Sunglasses" in Two Anoline Lizards from Cuba

In a number of lizards belonging to the families Lacertidae, Teiidae, and Scincidae and in *Cordylosaurus* (Gerrhosauridae) and *Lanthanotus* (Lanthanotidae), there is present in the lower eyelid a transparent or semitransparent "window" that permits some degree of vision when the eye is closed. This condition is thought to be a stage in the evolution of the "spectacle" found in certain genera of the Lacertidae, Teiidae, and Scincidae and in most geckos, all pygopodids, all xantusiids, and all snakes; in these the whole lower eyelid is transparent and fused to the upper lid as a permanent immobile protective cover for the eye.

In the course of study of the West Indian members of the genus *Anolis* (family Iguanidae), it was found that two closely related allopatric forms on Cuba have just such a semitransparent "window" as has been repeatedly described in lacertids, teiids, and so forth. In *Anolis lucius* three black-bordered semitransparent scales form most of the window Fig. 1); in *Anolis argenteolus* only two black-bordered semitransparent scales are involved (Fig. 2). In both forms the area of the lid window is small enough that, in a fully open eye, the window is completely concealed in a fold of the lower lid.

This appears to be the first record of such a condition in the family Iguanidae (although we believe that the phenomenon is commoner in lizards than the present published records indicate); moreover, the occurrence of a lower eyelid window in those anoles is also of interest for an ecological reason.

Barbour and Ramsden (*1*) found *A. lucius* in the vicinity of limestone cliffs, usually crawling about on the rocks at the entrance of caves. They record that although *A. argenteolus* also occurs on limestone it is found much more often than *lucius* on the trunks of trees or on the sides of buildings but usually only near outcroppings of limestone rock. More specific information is provided by Rodolfo Ruibal (University of California, Riverside) who has collected *A. lucius* in Camaguey, Cuba. He writes (*2*): "It is very typical of limestone cliffs and caves. However, like all animals it is sometimes found away from its 'typical' habitat. In caves it certainly is found anywhere in the twilight zone and of course runs out into the sun-lighted zone as well."

Two large recent collections of *A. lucius* have been made in caves; and both E. T. Willis (*3*), collecting in Oriente, and Wilfred T. Neil (*4*), collecting in Matanzas, were very much impressed with the geckolike appearance and actions of the species and their obvious adaptation to the twilight zone. The specimens collected by Willis were found on the cave walls 75 to 100 feet below the surface of the ground. Those collected by Neil were in the twilight zone, clinging upside down to the ceiling.

The Anolinae are typically diurnal, sight hunters in which vision plays a great part also in their sexual display and territoriality. Garth Underwood (*5*) has called attention to the adaptation of *Anolis* for an active diurnal arboreal life by his discovery of two foveae in the retinas of three Jamaican species of the genus. Only two species within this very large genus are suspected of having a partly cave habitat and a partly crepus-

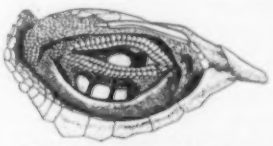

Fig. 1. Eye of *Anolis lucius*.

Fig. 2. Eye of *Anolis argenteolus*.

cular habitat. We think it is significant that these two species should also be the only ones with eyelid windows. (We have examined for this character every species of *Anolis* in the collections of the American Museum of Natural History and of the Museum of Comparative Zoology).

It is not to be expected that members of a genus specially adapted to diurnal habit could assume a semicrepuscular habitat without ophthalmological modifications. The retinas of *A. lucius* and *argenteolus* have not yet been examined, but we suspect some modification of the retina for greater sensitivity in dim light. The lid windows show that at least the superficial portions of the eyes are modified.

Walls (*6*) has argued that the function of lid windows and spectacles in Squamata is always protection against abrasion. They furnish protection against the soil in the case of burrowers, against sand in deserticolous forms, and in the case of small nocturnal forms they shield against hazards obscurely seen. But, whatever their value elsewhere, in the present instance none of these suggestions seem to apply. These anoles are neither burrowers nor deserticolous. They are partly crepuscular, but their lid windows would not be advantageous under crepuscular conditions; whether or not the windows are transparent in life (we have not seen live specimens of these species), these small slitlike multipaned windows with black borders must significantly limit the transmission of light. They must transmit more light than an opaque lid but obviously much less than the open eye. Thus they could not be used in the semidarkness of caves where restriction of light entering the eye would be meaningless if not deleterious.

It is to be emphasized that eyelids in tetrapods always have *two* functions: to guard the eye against foreign objects and against excess light. The lid windows in many lizards and the spectacles in other lizards and in snakes are large, round, and fully transparent; the original ability to limit or exclude light *by a lid* has been lost in these cases. The lid window in the Cuban anoles must be functionally very different.

If the effect of the anole lid window is to limit light entering the eye, then it must function not in the dimness of cave entrances (where maximum light utilization would be needed) but in the daylight outside caves. It may function, as Underwood (*7*) has emphasized to us, as a substitute for pupil mobility, since the general run of diurnal lizards have an iris that is very little responsive to changes in illumination.

We suggest therefore that the lid windows of these Cuban anoles function not, as in Walls' hypothesis, as protective "goggles" but as the equivalent of "sunglasses." They do protect, but they protect against the fierce light of the Antillean sun.

We must confess that in this comparison of lizard eyelid windows to sunglasses we have been preceded by Robert Mertens, who reports (*8*) that the desert-dwelling lacertids of the genus *Eremias* (in which some sort of lid window is frequently present) habitually shut their eyes when resting briefly in the full sun. He figures in one species (*E. u. undata*) just such a window formed of black-bordered scales as we have discovered in the Cuban anoles. Mertens explicitly compares this condition with the protection afforded by a "dunkle Brille" and further says of the black borders of the window scales that their meaning probably lies in protection against too strong and therefore damaging light.

Nor is Mertens' the earliest suggestion of this sort. Plate (*9*), discussing the eyelid windows of *Chalcides* and *Eremias*, commented: "Es ist dies wohl ein Mittel um all zu grelles Licht abzublenden." It seems probable to us that this explanation, which has been arrived at several times independently, may be the valid functional explanation of a number (although by no means all) of the many instances of eyelid windows in lizards (*10*).

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References and Notes

1. T. Barbour and C. T. Ramsden, *Mem. Mus. Comp. Zool.* 47, 73 (1919).
2. R. Ruibal, in a letter 19 Oct. 1954.
3. H. M. Smith and E. T. Willis, *Herpetologica* 11, 86 (1955).
4. W. T. Neil, in a letter 24 March 1955.
5. G. Underwood, *Nature* 167, 183 (1951).
6. G. Walls, *Am. J. Ophthalmol.* 17, 1045 (1934).
7. G. Underwood, in a letter 7 Feb. 1955.
8. R. Mertens, *Natur u. Volk* 84, 184 (1954).
9. L. Plate, *Allgemeine Zoologie und Abstammungslehre* (Jena, 1924), vol. 2, p. 675.
10. We gratefully acknowledge very useful suggestions by Garth Underwood. The problem has also been discussed with Rodolfo Ruibal, Jay M. Savage, and Gordon Walls.

20 June 1955

Effect of Size and Number of Brain Cells on Learning in Larvae of the Salamander, Triturus viridescens

To date relatively few studies have been made on learning in salamanders. In the Mexican axolotl, the snapping reflex was inhibited (*1*), and hearing has been investigated by classical conditioning techniques (*2*). Larvae of *Amblystoma paroticum*, when placed in a dry T-maze, learned a position habit, with return to water serving as reward for the correct response (*3*); however, Colorado axolotls (*Amblystoma tigrinum*) were unable to form this simple association. Recently it was shown that the strongly negative reaction of Mexican axolotls to blue light can be converted into a positive response by offering food (*4*).

Table 1. Number of trials required to reach criterion of learning and number of errors

Chromosome number	Code number	Positive stem of maze	Trials to criterion	Errors
Diploid	B	R	54	6
	C	R	30	9
	F	L	41	11
	G	L	30	10
		Mean	39	9
Triploid	A	L	76	25
	D	L	87	32
	E	R	126	41
	H	R	212	78
		Mean	125	44

In the newt, *Triturus viridescens*, and in other amphibians, the normal diploid chromosome number can be increased to the triploid by suppression of the second maturation division as a result of subjecting fertilized eggs to a temperature of 36°C for 10 minutes (*5*). The increase in the number of chromosome sets from two to three produces a proportionate increase of about 50 percent in the size of the cells. There is no increase, however, in the over-all body size of the triploid larvae; therefore, the number of cells must be reduced to about two-thirds of the normal to compensate for the larger cell size (*6–8*). Photographs of corresponding sections of the forebrain of a triploid and a diploid animal clearly show that the area of the transverse section is the same in both, but that the nuclei of the brain cells of the triploid are larger and fewer in number. Actual cell counts have not been made so far.

The purpose of this study (*9*) was to test the suggestion (*7*) that the smaller number and/or larger size of the brain cells of the triploid salamander larvae may affect their learning ability. The learning task was that of a simple position habit in a Y-maze. The animals were placed in the stem of the maze and prodded lightly on the end of the tail with a small blunt probe. This stimulation was repeated as many times as was necessary (usually only twice) to cause the animals to swim the length of the stem and to make a turn at the choice point. For half of the animals, turning right constituted a positive response that was rewarded by a 1½-minute rest period; for the remaining half of the animals, turning left was the positive response. A negative response produced a

period of compound punishment: the tactual stimulus continued, a 200-watt light came on, and then the animal was drawn up in a pipette and returned to the starting point of the maze. The maze was composed of eight individual Y's assembled in such a way that they formed an octagon. Thus, when an animal made a correct choice it was not necessary to remove it from the maze in order to start the next trial. Two continuous mazes were employed, one orientated to the left to be used where a left turn was positive, and one orientated to the right where a right turn was positive. The water in the mazes was always at room temperature.

The animals used in this study were four diploid and four triploid full-grown *Triturus* larvae between 100 and 104 days old. The animals were coded in such a manner that the experimenters had no knowledge of the type of larva being trained until the completion of all tests. The criterion for learning was 10 consecutive errorless trials. Each animal was kept in the maze until it reached criterion. Table 1 shows that the triploids, without exception, took more trials and made more errors than the diploids in order to reach criterion. The means are significantly different between the 2- and 5-percent levels of confidence.

These data demonstrate that the normal salamander larvae were capable of faster learning than the triploid. The slower learning of the latter cannot be attributed to an inability to respond properly to the tactual stimulus or to swim in normal fashion, as was shown by a test of their swimming ability in a technique devised by Detwiler (*10*).

It is not possible to decide at this time whether the difference in learning ability between diploid and triploid salamander larvae is connected with the difference in the total number of neurons and connections in the brain or with the difference in size of the individual neurons. Also, the possibility that differences in the number and size of peripheral nervous elements are partly concerned with the difference in performance has not been completely excluded.

Our experiments are somewhat related to those of Rensch (*11*) and his students who studied the effects on learning of differences in the size of the forebrain of closely related species or of races differing markedly in body size (mammals, fowl, and cyprinodont fish). In general, the brains of larger species or races contain more and larger ganglion cells. Actual tests of the learning ability revealed that races of small size learned easy tasks more quickly than larger animals, but that the latter could learn more difficult tasks and showed better retention. The interpretation of the results is complicated by the fact that the differences in learning performance are in part related to the greater liveliness and higher rate of metabolism of the smaller animals. Our experiments with salamanders of different chromosome numbers offer less complex conditions since the diploids and triploids are of the same size and do not seem to differ markedly in general reactivity and motility.

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References and Notes

1. V. Haecker, *Arch. ges. Psychol.* **23**, 1 (1912).
2. S. Ferhat-Akat, *Z. vergleich. Physiol.* **26**, 253 (1938).
3. A. R. Moore and J. C. Welch, *Proc. Soc. Exptl. Biol. Med.* **42**, 425 (1939); ———, *J. Comp. Physiol.* **29**, 283 (1940).
4. D. Trincker, *Z. vergleich. Physiol.* **36**, 115 (1954).
5. G. Fankhauser and R. C. Watson, *Proc. Natl. Acad. Sci. U.S.* **28**, 436 (1942).
6. G. Fankhauser, *J. Morphol.* **68**, 161 (1941).
7. ———, *Quart. Rev. Biol.* **20**, 20 (1945).
8. G. Fankhauser and B. W. Schott, *J. Exptl. Zool.* **121**, 105 (1952).
9. Supported in part by a grant-in-aid from the American Cancer Society upon recommendation of the Committee on Growth of the National Research Council and by the Eugene Higgins Fund of Princeton University. We wish to express our sincere thanks to Mrs. Kirsten Enander and Miss Jacqueline Mühlethaler for their valuable assistance in the preparation of the experiments.
10. S. R. Detwiler, *Am. J. Anat.* **78**, 115 (1946).
11. B. Rensch, in *Evolution as a Process*, J. Huxley *et al.* Eds. (London, 1954), p. 181.

2 June 1955

Production of Catalase Changes in Animals with 3-Amino-1,2,4-Triazole

In connection with some work on the effect of 3-amino-1,2,4-triazole (AT) (*1*) on chlorophyll synthesis in plants, we have observed that, in addition to the depressing effect that AT has on chlorophyll, it also causes a great decrease in the catalase activity of plant tissue. This observation prompted us to study the effect of AT on catalase in animals (*2*).

That a malignancy, anywhere in the animal body, causes a marked depression of liver and kidney catalase has been well established. It has recently been reported (*3*) that injection of extracts of tumor tissue also affects the liver catalase of animals. We have now been able to reproduce all the catalase changes occurring in a cancer host by the use of AT on a normal animal.

Adult female rats of the Long-Evans strain were used throughout this experiment. The AT was injected intraperitoneally as a sterile aqueous solution of 50 mg/ml. The dose varied between 250 and 1000 mg/kg of body weight. Control rats were injected with equal volumes of NaCl solutions adjusted to the same F.P. depression as the AT solution. Both injecting and sacrificing were done under light ether anesthesia. The animals were exsanguinated prior to removal of the liver and kidney. Catalase activity and nitrogen were determined by methods previously described (*4*).

Table 1 shows the levels to which catalase activity of the liver and kidney was lowered at various times after the injection of 1 g AT per kilogram of body weight as a percentage of control animals.

The blood catalase and the hemoglobin of the treated animals remained normal, and there were no evident toxic effects. The failure of AT to depress blood catalase activity makes its effect similar to that of malignant growth, since tumors also do not affect blood catalase. This observation lends further support to the views (*4*, *5*) that blood catalase differs in origin and, perhaps, in nature from that of liver and kidney catalase.

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References and Notes

1. We are indebted to the American Cyanamid Co., Agricultural Chemical Division, for the 3-amino-1,2,4-triazole.

Table 1. Effect of 3-amino-1,2,4-triazole on catalase activity of rats. (Dose: 1 g/kg of body weight.)

Hours after injection	*Liver*			*Kidney*		
	No. of animals	Units*/mgN	% of control	No. of animals	Units*/mgN	% of control
3	5	0.46 ± 0.06†	10.9	4	0.17 ± 0.03	12.8
6	6	0.50 ± 0.05	11.5	4	0.14 ± 0.04	10.3
12	6	0.72 ± 0.17	16.9	2	0.25 ± 0.02	18.4
24	6	1.51 ± 0.34	35.6	2	0.49 ± 0.11	35.7
48	6	2.74 ± 0.25	58.5	4	0.94 ± 0.16	71.6
72	6	3.64 ± 0.416	84.6	3	1.10 ± 0.23	85.5
Control	23	4.24 ± 0.50		18	1.36 ± 0.19	

* A unit of catalase is the amount that will liberate 1 ml of oxygen per second from a 1.0*N* H_2O_2 solution at 0°C. † ± Standard deviation.

2. This investigation was supported by a grant from Cancer Research Funds of the University of California.
3. W. Nakahara and F. Fukuoka, *Gann* 40, 45 (1949); R. E. Greenfield and A. Meister, *J. Natl. Cancer Inst.* 11, 997 (1951); H. H. Hirsch and W. Pfutzer, *Z. Krebsforsch.* 59, 611 (1953).
4. D. Appleman, E. R. Skavinski, A. H. Stein, *Cancer Research* 10, 498 (1950).
5. H. Theorell *et al.*, *Acta Chem. Scand.* 5, 445 (1951).

14 February 1955

Determination of Housefly Succinic Dehydrogenase with Triphenyltetrazolium and Neotetrazolium Chloride

The tetrazolium salts are being used with increasing frequency as convenient indicators of biological redox reactions and enzymatic activity (*1*). However, certain peculiarities associated with the reduction of the various derivatives have been noted. Brodie and Gots (*2*) and Throneberry and Smith (*3*) have observed that the rate of reduction of 2,3,5,-triphenyltetrazolium chloride (TPTZ) is increased by incubation in a vacuum, as have other authors, and various workers have suggested that there is a direct competition between the indicator and naturally occurring aerobic hydrogen carrier systems, a decrease in dehydrogenase activity in air, an elevation of the redox potential of the system in air to an unfavorable level for reduction of the tetrazolium salt, an alternate mechanism of reduction of the indicator in air as opposed to the anaerobic mechanism, or a toxicity manifested by the indicator per se. The rapidity of reduction of the tetrazolium derivatives by such enzymes as succinic dehydrogenase varies considerably; Glock and Jensen (*4*) found neotetrazolium [*p,p'*-diphenylenebis-2-(3,5-diphenyltetrazolium chloride)] to be a more sensitive indicator of plant succinic dehydrogenase than TPTZ.

In the course of an investigation (*5*) to determine the inhibition by DDT and related compounds of muscle succinic dehydrogenase of the housefly, *Musca domestica* L., with TPTZ and neotetrazolium, an interesting variability in performance was observed. This difference was also demonstrated by a comparison of the effect of sodium malonate, which is a competitive but weak inhibitor of succinic dehydrogenase, and sodium cyanide, which inhibits the cytochrome carriers strongly but not succinic dehydrogenase (*6*).

The determinations were made by incubating aliquots of homogenized thoraxes (8 per milliliter) of female adult houseflies in ignition tubes with 0.05*M* phosphate buffer (*p*H 7.4 final concentration) and the inhibitor for 30 minutes at room temperature, then adding 0.067*M* sodium succinate and 200 μg of indicator in aqueous solution, bringing the volume to 3.0 ml, and incubating at 35°C until measurable reduction of the indicator was observed. In anaerobic determinations the tubes were placed in a 3-lit filter flask, which was evacuated through a stopcock attached to the side arm. The formazan was extracted from each incubation mixture with 3.5 ml of water-saturated *n*-butanol (*4*) by shaking 50 times, followed by brief centrifugation to separate the layers. The optical density of the formazan extract was determined spectrophotometrically at 480 (TPTZ) or 520 (neotetrazolium) mμ. The amount of indicator reduced was read from standard curves prepared with known amounts of formazan.

Table 1. Effect of two indicators on the inhibition of housefly-muscle succinic dehydrogenase by sodium cyanide and sodium malonate. TPTZ determination, incubated 115 minutes; neotetrazolium determination, incubated 30 minutes

Inhibitor	Concn. (*M*)	Indicator reduced (μg)			
		TPTZ		Neotetrazolium	
		Aerobic	Anaerobic	Aerobic	Anaerobic
		35.4	39.2	50.4	87.8
Cyanide	6.7×10^{-4}	0	3.9	19.4	26.5
Cyanide	1.7×10^{-4}	0	15.2	20.6	32.8
Malonate	0.05	6.3	9.6	2.3	5.5
Malonate	0.017	21.2	24.5	2.8	7.3

Table 2. Influence of cytochrome *c* on cyanide inhibition, and of increased substrate concentration on malonate inhibition of housefly-muscle succinic dehydrogenase ($5 \times 10^{-4}M$ $CaCl_2$ added throughout; incubated in a vacuum 45 minutes)

Inhibitor	Concn. (*M*)	Reagent added	Concn. (*M*)	Indicator reduced (μg)	
				TPTZ	Neotetrazolium
				36.5	143.4
Cyanide	3.3×10^{-4}			4.0	156.0
Cyanide	3.3×10^{-5}	Cytochrome	1.7×10^{-6}	11.7	143.4
Malonate	0.017			20.0	58.0
Malonate	0.017	Succinate (2x)	0.067	26.0	125.1

TPTZ reduction (Table 1) was found to be more strongly inhibited by cyanide and less strongly inhibited by malonate than neotetrazolium, both aerobically and anaerobically. Furthermore, as is shown in Table 2, cyanide inhibition of TPTZ reduction was somewhat lessened by added cytochrome *c* (*7*). The effect of malonate was partially counteracted by increasing the substrate concentration, as would be expected. The addition of calcium chloride appeared to stimulate reduction but did not alter the relative effect of the inhibitors. The action of cyanide and malonate on neotetrazolium reduction is in agreement with the hypothesis that this tetrazolium compound is reduced directly by succinic dehydrogenase, while the results with TPTZ may indicate the mediation of a cyanide-sensitive hydrogen carrier. It is also possible that the difference in reactivity is an artifact arising not from differences in mode of reduction by the enzyme but from differences in solubility or reactivity of the tetrazolium derivatives themselves, which influence the availability of the indicator.

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References and Notes

1. F. E. Smith, *Science* 113, 751 (1951); J. H. Bodine and L. R. Fitzgerald, *J. Cellular Comp. Physiol.* 34, 521 (1949); C. O. Jensen, W. Sacks, F. A. Baldauski, *Science* 113, 65 (1951).
2. A. F. Brodie and J. S. Gots, *ibid.* 114, 40 (1951).
3. G. O. Throneberry and F. G. Smith, *ibid.* 117, 13 (1953).
4. E. Glock and C. O. Jensen, *J. Biol. Chem.* 201, 271 (1953).
5. This work was supported by a grant from the Rockefeller Foundation, New York. I wish to acknowledge the helpful advice of R. B. March, University of California Citrus Experiment Station, Riverside.
6. E. Baldwin, *Dynamic Aspects of Biochemistry* (Macmillan, New York, 1952).
7. From Nutritional Biochemicals Co.
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5 April 1954

Book Reviews

Operations Research for Management. Joseph F. McCloskey and Florence N. Trefethen, Eds. Johns Hopkins Press, Baltimore, Md., 1954. xxiv + 409 pp. Illus. $7.50.

This book is a highly interesting compilation of articles on various aspects of operations research, by a number of different authors. They were originally presented as talks at seminars on operations research jointly sponsored by the Operations Research Office (doing research under contract with the Department of the Army) and the Johns Hopkins University. Edited and published (with any profits to go to the advancement of operations research rather than to the authors, by the way), they should appeal particularly to two classes of readers who have heard lately a lot of discussion about operations research and what it can do for management.

For executives in business and industry it can throw some light (from several directions and variously polarized) on some questions that may have been bothering them, such as "What is this operations research all about, and what is new in it, if anything?" "Why should scientists become involved in management problems that have nothing to do with research and development?" or "How good are these new and powerful techniques the operations research people talk about?" Also, a person with scientific training and an urge to apply that training to solve large-scale problems, rather than to develop new trees for the forest, can get a good idea of the potential for working in operations research and how to add to his training the better to prepare for it.

As would be expected from such a compilation, there is some duplication and contradiction of points of view. In the opening part of the book, which deals with the history, characteristics, and organization of operations research, there is ample evidence of the immaturity of the field as a unified science. There is some whistling in the dark as the authors try to convince themselves and one another that operations research is really scientific in the sense that science is aimed more at understanding than toward immediate practical utility. Ellis A. Johnson, in his general introduction, stresses the elements of observation, the model, experimentation, verification, and prediction, but these elements are often lacking in the examples of operations research presented later in the volume. He makes again the often-heard point that operations research deals with the operations of a whole organization, serving the whole management, rather than with subsidiary problems. Here again, however, this is not borne out by example, and this seems to remain a goal rather than an accomplishment of operations research.

Florence N. Trefethen's chapter on history includes a bow in the direction of time-and-motion study, quality control, industrial engineering, and so forth, as cousins, if not the grandparents, of operations research, and notes the addition of broader points of view, new disciplines, and more sophisticated techniques. Her summary of university programs and organizations to develop operations research is especially helpful to the potential student in the field.

George S. Pettee, in his chapter on operations research as a profession, offers an interesting discussion of how professions start. He aptly likens the status of operations research to that of chemistry during the time between Lavoisier and the later fairly complete identification of that field. He hopes that ethics in operations research, as in other professions, will allow complete interchange of methodology—as opposed to results with their military or industrial secrecy. If in fact methodology is the key to success of operations research, this may require some education among management, which is notably reluctant to reveal any clues to competitive advantage.

Charles Goodeve's discussion of operations research as a science reveals a basic difference in viewpoint between this country and Britain, where the scientific approach with rather simple methodology is stressed rather than the sophisticated techniques stressed in the U.S. His chapter almost belongs among those of examples, since he illustrates well one of the best attributes of operations research, the transferability of a single method among problems in widely different fields.

Lawrence J. Henderson's part on organization for operations research recognizes that organization is no substitute for ability and that operations research will find the place in an organization consonant with its success. He demolishes other authors' concept of the "mixed team" for operations research as a morale-building metaphor born during personnel-scarce World War II and outlines the real mixed team of coordinated specialists.

J. W. Pocock compares management consulting and operations research. From the viewpoint of long experience in a well-established field, he takes operations research promoters to task for their insistence on "proper conditions" for operations research and their inability to communicate their product to management without either confusing complication or ridiculous oversimplification. He notes, however, that so far as technique is concerned, operations research may begin where industrial and management engineering stop—that the best minds for operations research are those that almost unconsciously translate the activities in the world about them into curves, parameters, tables, and equations.

P. M. Morse leads off the section on methodology with some prognostications on the growing diversified utility of some older analytic techniques and the need for new ones. As a scientist who has managed sizable enterprises, he recognizes that the processes of research and management are inimical—within the same person, at least—but foresees the partnership between executives and operations research teams that has become the usual pattern in military organizations.

Russell L. Ackoff's chapter on statistics in operations research will shake most executives' equanimity regarding the adequacy of their statistical staffs. He shows the importance of modern statistical methods if reliable and useful conclusions are to be reached with a reasonable amount of statistical analysis, balancing the cost of analysis against the consequences of resulting errors (as opposed to mistakes). One example demonstrates the usefulness of stratified sampling and optimum allocation to a normally nonscientific problem—interline settlements for railway freight shipments.

Chapters by Byron O. Marshall, Jr., on queueing theory and by David Slepian on information theory will probably introduce the reader to two useful techniques that have only recently been formalized in mathematical terms. Their versatility is astonishing, with queueing theory potentially useful wherever capacity, demand, and service interact—in cafeterias, airports, warehouses, telephone systems, or what-have-you.

A discussion by Charles Hitch and

Roland McKean on suboptimization presents not so much a method as a warning and some rules. To the manager who has judged his operation on subsidiary measures, such as production per man or the ratio of profits to costs, ignoring or suppressing such factors as capital requirements, or the efficiency of other parts of the enterprise, this chapter says beware, as it does to the operations research worker on his selection of his basic measure of effectiveness.

Chapters by Walter E. Cushen on symbolic logic, by Joseph E. Harrison, Jr., on linear programming, and by David H. Blackwell on game theory are the most technical in the book and discuss techniques for which wide usefulness in operating problems is potential rather than proved. In general, their computational complexity is such that examples are given only in oversimple problems. It is refreshing to note the authors' statements of the limitations surrounding each. But a chapter, also by Harrison, on the use of high-speed large-capacity computers in operations research gives promise that their employment will allow the routine use of such techniques in practical problems.

Joseph F. McCloskey introduces a section on case histories in operations research with the opinion that scientists can make a new contribution in the new environment of operating problems, because they command the mathematical tools that make it possible to reduce to principle and formula many variables that enter into consideration when major decisions must be made. He notes that most successful operations research has been in an atmosphere of detachment from direct responsibility for the operation, sufficient time for research, and the confidence of the responsible executive.

The several case histories that follow are an interesting cross section of what different workers in the field view as operations research, although allowances must be made for distortions due to paraphrase and condensation. The example by John F. Magee concerning the effect of promotional effort on sales should appeal particularly to the businessman. It deals with a problem close to his heart, clear improvement in the operation resulted through methods not normally at his disposal, the best principles of operations research were applied, and, best of all, he can probably understand most of the method. Charles Warren Thornthwaite's example of developing a climatic calendar for large-scale vegetable farming is a wonderful case of a scientist's being around, recognizing an important problem, and solving it in an almost offhand and obvious manner. It should be an everlasting refutation to some businessmen's reaction that "anybody" could do that—the fact is they had the opportunity to do so and did not. Horace C. Levinson's account of his operations research in the mail-order and department store businesses includes some interesting examples on the evaluation of advertising and night store hours that required some pretty good techniques, but others that seem to be indistinguishable from normal market research. A useful model for relating complexity and reliability of electronic equipment is discussed in David M. Boodman's chapter on the reliability of air-borne radar. It would seem to have obvious application to the setting of design and manufacturing standards for consumers goods, balancing costs of extra reliability against those of servicing and fulfilling guarantees.

In my opinion, examples by Alfred H. Hausrath on study of the utilization of Negro manpower in the Army and by Robert H. Roy on operations research in the printing industry were not suitable for inclusion in this volume. The first is social research, the second is methods research or industrial engineering—neither was dominated by quantitative analysis or met McCloskey's own criteria for operations research. One more case history, by Seymour T. R. Abt, dealt with opportunities for operations research in supermarkets rather than accomplishments.

In summary, the book is an excellent compendium for the reader who wishes to catch up on operations research and get a good idea of how it may be useful to management in business and industry. It suffers little from its multiple authorship and usefully draws together many of the bits and pieces in which information on this field existed heretofore. It will give the executive reader some uneasy moments as he wonders whether he is missing some good bets for improving his operations and whether he might better his competitive position by having some scientists messing around with his management problems.

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The Chemistry of Lipids of Biochemical Significance. J. A. Lovern. Methuen's Monographs on Biochemical Subjects. Rudolph Peters and F. G. Young, Eds. Methuen, London; Wiley, New York, 1955. xiii + 132 pp. $1.75.

J. A. Lovern has written a compact book that deals with the field encompassed by its title in five different chapters dealing, respectively, with the structure of lipids, their preparation and analysis, their condition in the tissue, their dynamic state, and, finally, their biological function. The subject matter is well distributed among these five different headings, and the result is an exceedingly readable little book that manages to impart an amazing amount of information in very little time. The facts and theories presented are clearly stated, critically evaluated, and woven into a logical whole.

Lovern is a well-known lipid biochemist. Therefore the book is the work of a specialist writing on his own field. Too often such authorship results in an exposition of the subject that is either too specialized or too general. Lovern has successfully avoided these twin pitfalls, and his book is, on the one hand, authoritative and thorough and, on the other hand, easy to understand. It should be useful both to the specialist and to the general biologist.

Coming shortly after the exhaustive works of Deuel and of Wittcoff, Lovern's small book might have run the danger of being overlooked. Its excellence will undoubtedly save it from such fate.

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A History of Dermatology in Philadelphia. Including a biography of Louis A. Duhring, father of dermatology in Philadelphia. Reuben Friedman. Froben, Fort Pierce Beach, Fla., 1955. 556 pp. Illus. $10.

To members of the medical and allied professions who have seen the exhibits of historical manuscripts presented at society meetings by Reuben Friedman and to those who have read his historical articles, monographs, and books on the discovery of the cause of scabies, his scholarship in the field of medical history needs no further elaboration. The author is also a dedicated dermatologist whose precepts I was fortunate in having during the formative years of my own training in the specialty.

Although it concentrates on the history of dermatology in Philadelphia, the treatise includes a background of national and international events in the growth of the specialty that affords an excellent perspective of the development of cutaneous medicine in the Quaker City. As a result, the volume will be found valuable by graduate students of dermatology in appreciating how definite names and descriptions of cutaneous disease entities crystallized from a heritage of confused and confusing nomenclature. In addition, physicians will gain from it an understanding of the growth of that body of specialized science: from Willan's classification of skin diseases and his modern concept of eczema, through Alibert's classification, to that of Hebra

on which the Philadelphia school was based.

The biographies of the patriarch, Louis A. Duhring, and his professional heirs and of John H. Stokes and his students constitute the history of dermatology in Philadelphia. In his book, the author has made the old schools come alive. He has illustrated the relationships of leading lights in Philadelphia dermatology by means of charts showing their spheres of influence.

His clear analysis of the development of dermatology in that city is made more lucid by means of insight into the lives and characters of Duhring and Stokes presented through the eyes of their contemporaries and students. It shows the profound influence that Duhring had during his lifetime, and even after death by means of his personal fortune, which was dedicated to what had been his sole interest in life—the advancement of the specialty of cutaneous medicine.

Of interest to physicians, as well as to those trained in law, will be the complete text of Duhring's will—a masterpiece of testamentary draftsmanship that covered every contingency and revealed further the personality of the testator.

Not least in interest are the author's philosophic comments in the preface and in a section on notes and errors, which cast light on the tribulations of historians. The book also gives an insight into the art of writing medical history; wherever possible the author makes use of memoirs written by contemporaries, adding percipient explanations only when necessary.

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Transactions of the Symposium on Computing, Mechanics, Statistics and Partial Differential Equations. Held at the University of Chicago 29–30 Apr. 1954. vol. II, Symposium on Applied Mathematics. F. E. Grubbs, F. J. Murray, and J. J. Stoker, Eds. Interscience, New York–London, 1955. iv + 216 pp. Illus. $5.

This second symposium volume, like the first, is reprinted from *Communications on Pure and Applied Mathematics* [8, No. 1 (1955)]. It contains three chapters dealing with numerical analysis, two with problems in mathematical statistics (and one with statistical mechanics), and two with differential equations. The remaining three chapters are devoted to operations research, elasticity, and stability in mechanical systems.

The papers are of fine quality. The one by Florent Bureau on "Divergent integrals and partial differential equations" gives a penetrating review of the subject, including an extensive bibliography. Several other papers provide useful bibliographies. This is particularly true of J. Neyman's "The problem of inductive inference"; H. O. Hartley's "Some recent developments in analysis of variance"; and John Todd's "Motivations for working in numerical analysis," an interesting and inclusive survey of the most significant aspects of modern research in the field.

Like Todd, most of the other authors have provided a review of the field mentioned in the title, sometimes by an incisive discussion of special problems. Two papers present approaches peculiarly identified with the authors. "The simplest rate theory of pure elasticity" by C. A. Truesdell sets forth a new concept for the study of elasticity and expounds the simplest ideas of the resulting theory. The paper by William Feller, "On differential operators and boundary conditions," discusses a generalization of a linear differential operator of second order and shows by examples the usefulness of the concept, even for classical problems.

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New Books

The Biology of the Spirit. Edmund W. Sinnott. Viking, New York, 1955. 180 pp. $3.50.

Genetics Is Easy. A handbook of information. Philip Goldstein. Lantern Press, New York, ed. 2, 1955. 238 pp. $4.

The Only Way Out. Jacob Rosin. American Press, New York, 1955. 114 pp. $2.95.

Yearbook of Anthropology, 1955. vol. 1. William L. Thomas, Jr., Ed. Wenner-Gren Foundation for Anthropological Research, New York, 1955. 836 pp.

Forestry Handbook. Reginald D. Forbes, Ed. Ronald Press, New York, 1955. 1200 pp. $15.

A History of Philosophy. B. A. G. Fuller; revised by Sterling M. McMurrin. Holt, New York, ed. 3, 1955. 618 pp. $6.90.

The Extra Pharmacopoeia. vol. 2. Pharmaceutical Press, London, ed. 23, 1955. 1501 pp. £2 17s. 6d.

Imagination's Other Place. Poems of science and mathematics. Compiled by Helen Plotz. Crowell, New York, 1955. 200 pp. $3.50.

Hawley's Technical Speller. Compiled by Gessner G. Hawley and Alice W. Hawley. Reinhold, New York; Chapman & Hall, London, 1955. 146 pp. $2.95.

The Permanent Revolution in Science. Richard L. Schanck. Philosophical Library, New York, 1954. 112 pp. $3.

World Economic Geography with Emphasis on Principles. Earl B. Shaw. Wiley, New York; Chapman & Hall, London, 1955. 582 pp. $6.50.

Miscellaneous Publications

(Inquiries concerning these publications should be addressed, not to Science, but to the publisher or agency sponsoring the publication.)

The Helen Hay Whitney Foundation Second Report, for the Years 1950–1954. The Foundation, New York, 1955. 60 pp.

Report to Congress on the Mutual Security Program for the Six Months Ended June 30, 1955. Superintendent of Documents, GPO, Washington 25, 1955. 60 pp. $0.45.

Report on the Foundation's Activities for the Year Ended January 31, 1955. Wenner-Gren Foundation for anthropological Research, New York, 1955. 84 pp.

The Bromeliaceae of Brazil. Misc. Coll., vol. 126, No. 1. Lyman B. Smith. Smithsonian Institution, Washington, 1955. 290 pp.

Polio and the Salk Vaccine. Public Affairs Pamphlet No. 150A. Roland H. Berg. Public Affairs Committee, New York 16, 1955. 28 pp. $0.25.

Proceedings of the Third Japan National Congress for Applied Mechanics, 1953. 1954. 442 pp. *Proceedings of the Fourth Japan National Congress for Applied Mechanics, 1954.* 1955. 468 pp. Ed. by Japan National Committee for Theoretical and Applied Mechanics. Science Council of Japan, Tokyo.

Geology of Southern California. Bull. 170. Div. of Mines, Dept. of Natural Resources, San Francisco 11, Calif., 1954. 878 pp. (10 separately bound chapters, 34 map sheets, and 5 road logs, boxed.) $12.

Museum at Work. Bernice P. Bishop Museum annual report for 1954. The Museum, Honolulu, 1955. 55 pp.

Uranium Prospecting in Canada, Ground and Aerial Surveys. AECL No. 200. A. H. Lang. 22 pp. *Canadian Practice in Ore Dressing and Extractive Metallurgy of Uranium.* AECL No. 201. A. Thunaes. 9 pp. *Electric Power in Canada.* Regional forecasts in relation to nuclear power possibilities. AECL No. 202. J. Davis. 11 pp. *Some Economic Aspects of Nuclear Fuel Cycles.* AECL No. 203. W. B. Lewis. 30 pp. *Health and Safety Activities in Reactor Operations and Chemical Processing Plants.* AECL No. 207. A. J. Cipriani. 8 pp. *Studies of Special Problems in Agriculture and Silviculture by the Use of Radioisotopes.* AECL No. 209. J. W. T. Spinks. 33 pp. *Current Techniques in the Handling and Distribution of Cobalt 60 Radiation Sources.* AECL No. 212. A. B. Lillie. 16 pp. Atomic Energy of Canada, Chalk River, Ontario, 1955.

The Prevention of Occupational Skin Diseases. Louis Schwartz. Assoc. of American Soap and Glycerine Producers, New York 17, 1955. 42 pp.

Proceedings of the Fourth Meeting of the Mixed Commission on the Ionosphere of the International Council of Scientific Unions. Held in Brussels, 16–18 Aug. 1954. 238 pp. $6. *Proceedings of the XIth General Assembly of the International Scientific Radio Union.* Held in The Hague, 23 Aug.–2 Sept. 1954. vol. X, pt. 4, *Commission IV on Radio Noise of Terrestrial Origin.* 60 pp. $1.20. International Scientific Radio Union, Brussels, 1955.

Scientific Meetings

International Astronomical Union

The 9th general assembly of the International Astronomical Union took place in Dublin between 29 Aug. and 5 Sept. About 650 astronomers from 41 countries attended two general assembly meetings and several dozen scientific symposia and discussion groups. Thirty-seven of the 41 countries officially adhere to the union. The largest delegation, of 110 astronomers, came from the United States. More than 100 astronomers represented Great Britain and Northern Ireland. The Soviet Union sent 21 delegates. Communist China was represented by four delegates. They, and the delegation from Argentina, had come in response to an official appeal by the president, who had stressed the importance to astronomy of securing the widest possible distribution of astronomical observations over the surface of the earth. Some of the scientific highlights of the meeting were the following.

1) M. Walker (Mount Wilson and Palomar) demonstrated a periodic variation in the brightness of DQ (Nova) Herculis, outside of eclipse, with a period of about 64 seconds and an amplitude of several hundredths of a magnitude (10 or more times greater than the accidental scatter). This ushers in a new era of *micro*-astronomy.

2) J. H. Oort and Th. Walraven (Leiden, Holland) reported their observations of the plane-parallel polarization of the light of the amorphous part of the Crab nebula, which reaches nearly 100 percent in certain regions. This result, already foreshadowed by work of Vashakidze and Dombrovsky in the U.S.S.R., implies that the continuous radiation of the nebula is due to electrons of 2×10^{11} electron volts of energy in a magnetic field of the order of 10^{-3} gauss. The total energy of the particles in the nebula is about 1/1000 of the entire amount of energy available inside the sun by the conversion of all of its hydrogen into helium.

3) R. R. McMath and L. Goldberg (Michigan) demonstrated solar spectra obtained with a large vacuum spectrograph. The Doppler effects of the turbulent motions of the granules and the variations in the Stark broadening of the hydrogen lines are correlated with local fluctuations of temperature on the solar disk. This opens up a new field of solar research.

4) W. Baade (Mount Wilson and Palomar) presented his structural analysis of the Andromeda galaxy with its sharply defined spiral arms of dust, gas, and young stars and its large "halo" of old stars and globular clusters. This analysis permits far-reaching conclusions with regard to the structure of the Milky Way.

5) G. Herbig (Lick Observatory) reported his discovery of several new luminous objects—which may be proto-stars—in the Orion nebula.

6) C. Fehrenbach (France), and C. Schalén (Sweden) presented their measurements of stellar radial velocities with objective prisms. These astronomers have finally succeeded in developing an optical system sufficiently free of systematic field corrections to produce reliable results for large numbers of very faint stars. This should revolutionize our knowledge of the kinematics of the Milky Way.

7) G. G. Getmanzev, K. S. Stankevich, and V. S. Troitsky (U.S.S.R.) announced that they have detected an absorption line at 91.6 centimeters in the radio-emission spectrum of the central bulge of the Milky Way. They identify this line with the forbidden transition of interstellar deuterium (as predicted by Shklovsky) and derive for the latter a preliminary value of the concentration that is 1/300 of the concentration of hydrogen.

The general membership of the union, as approved in Dublin, was proposed by a nominating committee under the chairmanship of W. M. H. Greaves (Scotland). Each national committee had previously been requested to submit lists of their nationals to the nominating committee; these lists were then scrutinized by the chairmen of the various standing commissions, and their recommendations were in all cases referred back to the national organizations. Hence, as the lists of members of the commissions now appear in the mimeographed bulletin distributed at Dublin, they reflect essentially the wishes of the national organizations.

Beginning at the present time the by-laws have been changed in such a way that they provide for "general membership" in the union without assignment to any particular commission. The purpose of this change (proposed by a committee consisting of Oort, H. Spencer Jones, P. G. Kulikovsky, and B. Strömgren) is to reduce gradually the numbers of persons assigned to standing commissions and ultimately also to reduce the number of separate commissions and subcommissions.

The principal aim of the union is to plan research for the future. The symposia, joint discussions, and conferences of standing commissions form the necessary background for this planning. They are not, therefore, primarily intended as a medium for the communication of results already obtained. Lack of understanding on the part of many astronomers of this basic principle has led to a tremendous amount of pressure on the part of enthusiastic research workers who come to the meetings loaded with papers, slides, and so forth, and who expect to be assigned time on the program for the presentation of their results. It should be clearly understood that the organizers of the symposia and other scientific conferences do not necessarily invite as speakers those astronomers who have produced the most significant advances. They are expected to encourage work in neglected fields, to stimulate new types of research in countries that have lagged behind, and to bring together workers from different areas in order to promote a new type of research. An interesting example of the latter type of conference was the joint discussion on image tubes organized by a special committee under W. A. Baum (Mount Wilson and Palomar). The speakers included a number of astronomers (A. Lallemand, Baum, W. A. Hiltner, R. Morgan, R. Sturm, and A. Wilson) and representatives of the electronics industry (G. A. Morton and others).

The union accepted an invitation from the U.S.S.R. to meet in Moscow in 1958. All individual members of the IAU are included in this invitation. They will be the guests of the Soviet Academy of Sciences while they are on Russian soil. Members of their families will be expected to pay 400 rubles ($150) per person, and their needs will be taken care of by the Soviet organization. J. J. Nassau (chairman of the U.S. delegation) extended an invitation to the union, on behalf of the State Department, to meet in this country (probably in Pasadena, Calif.) in 1961; D. H. Menzel, president of the American Astronomical Society, spoke on behalf of the society, the National Academy of Sciences, and the National Research Council.

The entire meeting was held in an atmosphere of genuine friendliness and cooperation. The union is deeply grateful to

the Soviet astronomers who presented all of their symposium papers in English or in French and once again demonstrated to the world not only their linguistic proficiency but also their desire to make the sessions as efficient as is possible. In her concluding remarks, Mrs. A. G. Massevich expressed the hope that by 1958 the Western astronomers would know enough Russian to remove the necessity of her reading so many English translations of Russian contributions. Can we meet this challenge?

Despite the all-pervading "spirit of Geneva," it would be unrealistic not to recognize that the ideological differences between the West and the East have not been reconciled. We have found a *modus vivendi,* and we have intentionally shoved into the background those very serious philosophic problems that divide us. The time has come to discuss them frankly and with respect for one another's views. Perhaps we can gradually reach a common understanding.

The local arrangements in Dublin were perfect. Professor and Mrs. H. A. Brück of the Dunsink Observatory and Professor and Mrs. T. Nevin of the physics department of University College had foreseen every detail. We were entertained by the President of Eire at a large garden party and by An Taoiseach (Prime Minister John Costello) at an evening reception in St. Patrick's Hall of Dublin Castle. The Prime Minister and Mr. Eamon de Valera spoke at the ceremonial opening of the congress on 29 August, and both were the guests of the union at the closing dinner on 5 Sept.

Two large receptions were arranged by the U.S. Ambassador, Mr. William Howard Taft, III, and Mrs. Taft, at the American Embassy, and by the Soviet delegation at the Hibernia Hotel (there is no Soviet embassy in Dublin). Most of the other embassies had smaller parties for their own nationals. The Archbishop of Dublin gave a small dinner for Baade, Woolley, and Struve. After the official close of the meeting many delegates traveled by train to Belfast where they were entertained by the Prime Minister of Northern Ireland and were given an opportunity to visit the Armagh Observatory.

OTTO STRUVE

Department of Astronomy,
University of California, Berkeley

Meeting Notes

■ The fall meeting of the American section of the International Scientific Radio Union (URSI) will take place at the University of Florida, 15–17 Dec. A combined technical session for all participants is scheduled for the morning of 15 Dec.; this will be followed by one or more sessions in each of the following fields: commission 2, radio and troposphere; commission 3, ionospheric radio; commission 4, radio noise of terrestrial origin; and commission 5, radio astronomy.

Authors are invited to submit titles and 100 to 200 word abstracts *on or before 21 Oct. 1955.* The abstracts should be sent to the appropriate commission chairman or secretary: commission 2, Dr. J. B. Smyth, U.S. Naval Electronics Laboratory, San Diego 52, Calif.; commission 3, Dr. L. A. Manning, Electronics Research Laboratory, Stanford University; commission 4, Prof. A. W. Sullivan, University of Florida; commission 5, Mr. Fred T. Haddock, Naval Research Laboratory, Code 7130, Washington 25, D.C.

■ The third Buena Vista Conference on Biophysics was held at Hartford Manor, Valhalla, N.Y., 8–10 Sept. The conference, sponsored by the Yale University biophysics department and the John Hartford Foundation, was devoted to training and careers in biophysics.

Under the chairmanship of E. C. Pollard, the meetings were attended by representatives of universities, industry, government, hospitals, and private research laboratories. Sessions were devoted to defining the field of biophysics, determining careers available in biophysics, graduate and undergraduate training, and problems of publications and communication.

■ The eighth annual conference on Electrical Techniques in Medicine and Biology, sponsored by the American Institute of Electrical Engineers and the Instrument Society of America, will be held 14–16 Nov. at the Shoreham Hotel, Washington, D.C. The purpose of the meeting is to provide liaison and better understanding among workers in electronic engineering, medical research, and related disciplines to advance the development and application of electric techniques in medicine and biology.

Fourteen papers will be presented on "Recent advances in angiocardiography," "Audiology and instrumentation for hearing," and "Instrumentation in medicine and biology." Chairmen of the three sessions are Theodore F. Hilbish, chief of the diagnostic radiology service, National Institutes of Health, Bethesda, Md.; Scott Reger of the department of otolaryngology, University of Iowa Hospital, Iowa City; and W. A. Wildhack, chief of the Office of Basic Instrumentation, National Bureau of Standards, Washington, D.C. The conference will include inspection trips to the National Institutes of Health, the Naval Medical Research Institute, and the National Bureau of Standards.

■ The American Psychosomatic Society will hold its annual meeting at the Sheraton Plaza Hotel in Boston, Mass., 24–25 Mar. 1956. The program committee would like to receive titles and abstracts of 20-min papers *no later than 1 Dec.* Abstracts should be submitted in sextuplicate to the committee chairman at 551 Madison Ave., New York 22.

Society Elections

■ International Astronomical Union: pres., A. Danjon, Paris, France; past pres., Otto Struve, University of California, Berkeley; general sec., P. Th. Oosterhoff (Netherlands). The vice presidents are A. Couder (France), O. Heckmann (West Germany), B. V. Kukarkin (U.S.S.R.), E. Rybka (Poland), P. Swings (Belgium), and R. v.d. R. Woolley (Australia).

■ Illuminating Engineering Society: pres., R. F. Hartenstein, Ohio Edison Co.; general sec., George J. Taylor, Day-Brite Lighting, Inc., New York; treas., J. S. Schuchert, Duquesne Light Co., Pittsburgh, Pa. The vice presidents are M. N. Waterman, Westinghouse Electric Corp., Bloomfield, N.J., and Kirk M. Reid, General Electric Co., Nela Park, Cleveland, Ohio. Regional vice presidents are John G. Felton, Jr., Sylvania Electric Products, Inc., Dallas, Tex.; J. Dixon Mitchell, Westinghouse Lamp Division, Chamblee, Ga.; Joseph Thomas, Canadian General Electric Co., Ltd., Montreal, Canada; Nelson C. Warner, Westinghouse Electric Corp., Pittsburgh, Pa.; and J. D. Whitnell, Arizona Public Service Co., Phoenix, Ariz.

■ Botanical Society of America: pres., Harriet B. Creighton, Wellesley College; v. pres., William Randolph Taylor, University of Michigan; sec., Harold C. Bold, Vanderbilt University; treas., Harry J. Fuller, University of Illinois.

Forthcoming Events

November

14–16. Technical Conf. on Electrical Techniques in Medicine and Biology, 8th annual, Washington, D.C. (T. Rogers, Machlett Laboratories, 1063 Hope St., Springdale, Conn.)

14–17. International Automation Exposition, 2nd, Chicago, Ill. (R. Rimbach Assoc., 845 Ridge Ave., Pittsburgh 12, Pa.

14–17. American Petroleum Inst., 35th annual, San Francisco, Calif. (API, 50 W. 50 St., New York 20.)

14–18. American Public Health Assoc., Kansas City, Mo. (R. M. Atwater, APHA, 1790 Broadway, New York 19.)

14–18. New England Inst. for Hospital Administrators, 7th, Boston, Mass. (D.

Conley, ACHA, 620 N. Michigan Ave., Chicago 11, Ill.)

15–17. American Meteorological Soc., Honolulu, Hawaii. (K. C. Spengler, AMS, 3 Joy St., Boston 8, Mass.)

15–17. Geophysical Soc. of Hawaii, Honolulu. (L. Eber, Pineapple Research Inst., Honolulu.)

16–17. Industrial Hygiene Foundation, 20th annual, Pittsburgh, Pa. (C. R. Walmer, IHF, Mellon Inst., Pittsburgh.)

16–18. Soc. for Experimental Stress Analysis, Chicago, Ill. (W. M. Murray, SESA, Box 168, Cambridge 39, Mass.)

17–19. American Anthropological Assoc., Boston, Mass. (W. S. Godfrey, Jr., Logan Museum, Beloit College, Beloit, Wis.)

18–19. American Mathematical Soc., Knoxville, Tenn. (E. G. Begle, Yale Univ., New Haven 11, Conn.)

18–19. North Carolina Science Fair Work Conf., Greensboro. (D. E. Large, Science Fair Program, P.O. Box 117, Oak Ridge, Tenn.)

22–23. National Council of Geography Teachers, Indianapolis, Ind. (I. C. Robertson, State Teachers College, Valley City, N.D.)

22–25. International Cong. on Documentation of Applied Chemistry, 1st, London, Eng. (Cong. Committee, 56 Victoria St., London, S.W.1.)

25–26. American Mathematical Soc., Milwaukee, Wis. (E. G. Begle, Yale Univ., New Haven 11, Conn.)

25–26. American Physical Soc., Chicago, Ill. (K. K. Darrow, Columbia Univ., New York 27.)

25–26. American Soc. of Animal Production, annual, Chicago, Ill. (W. M. Beeson, Animal Husbandry Dept., Cornell Univ., Ithaca, N.Y.)

27–30. American Inst. of Chemical Engineers, Detroit, Mich. (F. J. Van Antwerpen, AIChE, 25 W. 45 St., New York 36.)

28–1. White House Conf. on Education, Washington, D.C. (C. Pace, Director; Comm. for White House Conf. on Education; South Health, Education and Welfare Bldg.; Washington 25.)

29–2. American Medical Assoc., clinical, Boston, Mass. (G. F. Lull, AMA, 535 N. Dearborn St., Chicago 10, Ill.)

29–2. Entomological Soc. of America, Cincinnati, Ohio. (R. H. Nelson, 1530 P St., NW, Washington 5.)

December

2. American Alpine Club, annual, New York, N.Y. (J. C. Oberlin, 909 Leader Bldg., Cleveland 14, Ohio.)

2–3. American Federation for Clinical Research, Eastern, Philadelphia, Pa. (C. R. Shuman, Temple Univ. Hospital, Broad and Ontario Sts., Philadelphia 40, Pa.)

2–3. Oklahoma Acad. of Science, Norman. (D. E. Howell, Dept. of Entomology, Oklahoma A. & M. College, Stillwater.)

2–4. American Psychoanalytic Assoc., New York, N.Y. (J. N. McVeigh, 36 W. 44 St., New York 36.)

4. American Acad. of Dental Medicine, 10th mid-annual, New York, N.Y. (G. J. Witkin, 45 South Broadway, Yonkers 2, N.Y.)

8–10. Florida Acad. of Sciences, Miami. (R. A. Edwards, Geology Dept., Univ. of Florida, Gainesville.)

9–10. Assoc. for Research in Nervous and Mental Disease, 35th annual, New York, N.Y. (C. C. Hare, 710 W. 168 St., New York 32.)

9–10. Texas Acad. of Science, annual, Waco. (G. P. Parker, P.O. Box 7488, College Station, Texas.)

9–13. American Acad. of Optometry, Chicago, Ill. (C. C. Koch, 1502 Foshay Tower, Minneapolis 2, Minn.)

10–16. Nuclear Cong. and Atomic Exposition, Cleveland, Ohio. (A. F. Denham, 931 Book Bldg., Detroit 26, Mich.)

10–16. Radiological Soc. of North America, Inc., Chicago, Ill. (D. S. Childs, Sr., 713 East Genesee St., Syracuse 2, N.Y.)

11–14. American Soc. of Agricultural Engineers, Chicago, Ill. (F. B. Lanham, ASAE, St. Joseph, Mich.)

11–14. American Soc. of Refrigerating Engineers, New York, N.Y. (R. C. Cross, ASRE, 234 Fifth Ave., New York 1.)

15–17. Acoustical Soc. of America, Providence, R.I. (W. Waterfall, ASA, 57 E. 55 St., New York 22.)

16–21. Interamerican Cong. of Psychology, 3rd, Austin, Tex. (W. Holtzman, Univ. of Texas, Austin.)

(See 16 September issue for comprehensive list)

Equipment News

■ ELECTRONIC COLOR MICROSCOPE developed by CBS Laboratories has magnifying power sufficient to project images of cancer cells to a diameter of 7½ in., red corpuscles to 5 in. in size, and the typhoid bacillus to ½ in. The system enables microscopic specimens, living or dead, to be enlarged and projected electronically on a 6-ft screen with resultant images many times brighter than those produced by conventional optical methods. It also permits the transmission of such images via the cable and microwave facilities of television to distant points. The new microscope is expected to assist scientists in the study of polarization and dark-field and other phenomena heretofore obscure because of their sensitivity to light. The new projection system was demonstrated at the annual meeting of the American Medical Association in Atlantic City, N.J. (Columbia Broadcasting System, Inc., Dept. Sci., 485 Madison Ave., New York 22.)

■ AIR-WELL BATH for detection of free and corrosive sulfur compounds in aviation gasoline, motor gasoline, cleaners' solvent, fuel oil, and certain other petroleum products consists of a constant-temperature bath and a constant-level device with a steam-tight cover and four air wells. Each air well has a glass condenser mounted on a cork disk. Cover construction is stainless steel; fittings are chrome plated. Thermostatic control, heater, and wiring are mounted in an accessible control compartment. (Modern Laboratory Equipment Co., Inc., Dept. Sci., 1809 First Ave., New York 28.)

■ NEW CHEMICALS available from Bios Laboratories include the following: 4-aminopyridine, $C_5H_6N_2$; azuric acid, $C_4H_5N_5O_3$; 9-bromophenanthrene, $C_{14}H_9Br$; cetylbenzene, $C_{22}H_{38}$; DL-chlorosuccinic acid, $C_4H_5O_4Cl$; 2,4-dimethylthiazole, C_5H_7NS; ethyl pyruvate, $C_5H_8O_3$; L-hydroxyanthraquinone, $C_{14}H_8O_3$; *p*-iodophenol, C_6H_5IO; and propiolic acid, $C_3H_2O_2$. (Bios Laboratories, Inc., Dept. Sci., 17 W. 60 St., New York 23.)

■ NUCLEAR INSTRUMENT CATALOG that describes radiation measuring equipment, radiochemicals, and accessories for medical, industrial, and research applications has been released by the Nuclear Instrument and Chemical Corp. Photographs and descriptions of scalers, count rate meters, portable instruments, and proportional and scintillation counters, as well as a radiochemical price list, are included. Catalog P. (Nuclear Instrument and Chemical Corp., Dept. Sci., 229 W. Erie St., Chicago 10, Ill.)

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Program content

1. The four-session symposium, "Atomic Energy and Agriculture," arranged by ORINS.
2. The three-session program of the International Geophysical Year.
3. An AAAS-sponsored "Congress" on the shortage of young scientists and science teachers.
4. Programs of the 17 AAAS sections (symposia and contributed papers).
5. Programs of the more than 60 participating societies.
6. The Special Sessions: AAAS, Academy Conference, Conference on Scientific Editorial Problems, National Geographic Society, Phi Beta Kappa, RESA, Sigma Xi.
7. Details of the Municipal Auditorium—center of the Meeting—and hotels and campuses.
8. Titles of the latest foreign and domestic scientific films to be shown in the AAAS Science Theatre.
9. Exhibitors in the 1955 Annual Exposition of Science and Industry and descriptions of their exhibits.

Directory content

1. AAAS officers, staff, committees for 1955.
2. Complete roll of AAAS presidents and their fields.
3. The more than 265 affiliated organizations.
4. Historical sketch and organization of the Association; the Constitution and Bylaws.
5. Publications of the Association.
6. AAAS Awards and Grants—including all past winners.
7. Membership figures by sections.
8. Section committees (Council members) in detail.
9. Local committees.
10. Future Meetings of the AAAS through 1962.
11. New and current activities of the AAAS.

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GRANTS

1956 Research Grants

The Arctic Institute of North America is offering research grants in 1956 for scientific investigations dealing with the arctic and subarctic regions of North America. Applications for research grants are invited from those who have demonstrated their ability to conduct research work of superior quality in some field of science. Proposals in the broad field of the earth sciences, in marine biology, and in physiology are especially invited. Facilities of the Arctic Research Laboratory at Barrow, Alaska, including housing and equipment, are available to scientists for both summer and winter investigations. Completed applications should be received before 1 November, 1955. For information and forms write Arctic Institute of North America, 1530 P. Street, N.W., Washington 5, D.C., or 3485 University Street, Montreal 2, Quebec, Canada.

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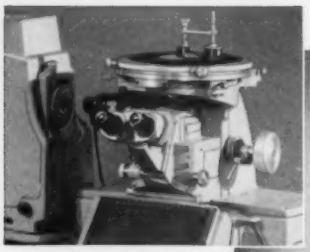

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